OFAT

Ontario Flow Assessment Techniques
Version 1.0

User's Manual

by
Chiadih Chang
Fiona Ashenhurst
Steve Damaia
William Mann

Ontario

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Chiadih Chang
Fiona Ashenhurst
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CENTRE

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- Water Management Section, MNR
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OFAT Development Team

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Fiona Ashenhurst – Aquatic Science GIS Specialist
Steve Damaia – GIS Database Specialist
William Mann – GIS Programmer

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Using the OFAT Manual

This section can be used as a roadmap for guiding you through the OFAT User's Manual. It will help you to efficiently use this manual. It also explains any conventions that are followed throughout. Although this manual describes some ArcView functions, it was designed for those who are already familiar with ArcView. It is not intended to take the place of an ArcView GIS manual. Refer to the ArcView User's Manuals listed in the References for further details on how to use ArcView's standard features.

The following summarizes the contents of each chapter:

- The Welcome chapter will provide introductory information to answer the "What? Why? Who? How?" questions related to OFAT, including system requirements and where to get help.
- The OFAT installation chapter will instruct the user how to install OFAT software and/or databases properly.
- The Getting Started chapter is designed to help OFAT users get up and running quickly. It describes how to start, run, and exit OFAT.
- Four chapters are then presented which describe, in detail, functions related to the four major steps involved in OFAT operation including:
    - Watershed Delineation
    - Watershed Calculator
    - Hydrologic Modelling
    - Watershed Information Extraction System (WIES)
- The Batch Run chapter describes the module which allows the delineation, parameter calculations, and flow modelling for multiple (or single) watersheds in the same batch run without constant user interventions.
- The OFAT Data Structure chapter describes the application and database directory structures in the user's hard drive after installation.
- The OFAT Metadata chapter outlines information about the OFAT data to keep track of large databases associated with the application.
- The Frequently Asked Questions (FAQ) chapter can be used to find answers to questions you may have about OFAT software and databases.
- The Troubleshooting chapter is where you can go for help to solve problems encountered when running OFAT.
- The Glossary will provide definitions to key words, abbreviations, and technical terminology used in this manual.

Following the main body of the User's Manual, the following appendices are also included:

- Appendix A: Corresponding UTM Zones for Major Basins of Ontario – where you can find the UTM zone information for data pertaining to each of major basin of Ontario.
- Appendix B: Watershed Calculator Parameter Descriptions – where you can find symbols, detailed descriptions, and units used for all watershed parameters calculated by the Watershed Calculator.
- Appendix C: Runoff Curve Number (CN) – where you can find detailed information about how the CN databases included in OFAT were created.

- Appendix D: Hydrological Models – where you can find descriptions and limitations of each of the flow models currently in OFAT.
- Appendix E: Flow Charts – where you can find schematic flow charts for all functions found in the OFAT software. Each flow chart breaks down each function into step-by-step procedures. These flow charts will help you understand how each function works and how it links to other relevant functions.

The OFAT Quick Reference Card, accompanied with this manual, includes a simplified flow chart to outline OFAT processes as well as basic information about using OFAT tools and buttons.

Typographic Conventions

The following additions to the text are intended to make it easier to follow the manual and learn OFAT:

✎ ***Note**: Contains tips, time savers and general information that may not be apparent.*

! ***Warning**: Cautions when an irreversible change is about to be performed, and flags critical operations.*

Words with the first letter capitalized and in single quotes represent OFAT interface functions accessed from menus, buttons, tools, icons and dialog box options. For example:

select the 'Watershed Delineation' item from the 'OFAT' pull down menu

Italicized font indicates a reference to a file. For example:

name the OFAT project file *ofat.apr*

The word "drive" is used to represent the location of the OFAT software and databases, depending on the context that the word is used in. For example, the "drive" could be the c: drive, the d: drive, the e: drive, etc.

How OFAT Maps Are Referenced

Throughout the text, four different ArcView maps are referenced. It is important that you learn to distinguish which map you are in, as the functions available in each map are different. These four maps are referred to as:

- **Basin Index Map of Ontario**: The map that opens automatically when you start OFAT. It contains an index map of 13 predefined major basins in Ontario. From this map, you can select a major basin of your interest.
- **Tertiary Watershed Index Map**: The map that opens automatically after you select a basin from the 'Basin Index Map of Ontario'. It contains tertiary watersheds within the selected basin. The title of the map will correspond with the name of the selected basin. From this map, you can select a tertiary watershed in which the watershed outlet of your interest is located.
- **Selected Watershed Area Map**: The map that opens automatically after you select a tertiary watershed from the Tertiary Watershed Index Map. It contains DEM-related databases (such as DEM, flow direction, flow accumulation, and calculated raster drainage network) and base map data layers (such as road, river, and lake) pertaining to the selected tertiary watershed. From this map, you can perform primary OFAT functions associated with the Watershed Delineation, Watershed Calculator, WIES, Flow Prediction Models, and Output Results.
- **Watershed Information Extraction Map**: The map that displays extracted data layers within a watershed boundary while using WIES. From here, the WIES Summary Statistics tool can be accessed.

Welcome to OFAT

What is OFAT?

The Ontario Flow Assessment Techniques (OFAT) Version 1.0, developed by the Northeast Science & Information (NESI) Section of the Ministry of Natural Resources (MNR), is a tool to automatically estimate flow information for watersheds in Ontario (Chang *et al.*, 2002). OFAT is a user-friendly, interactive Geographic Information System (GIS)-based software with accompanying databases used to estimate various flow regimes. These flow regimes include low flows (e.g., $7Q_2$, $7Q_{10}$, $7Q_{20}$, etc.), flood flows (e.g., Q_2, Q_{10}, Q_{25}, Q_{100}, etc.), mean annual flows, minimum instream flow requirements, and bankfull flows. OFAT has been created by automating a number of existing regional hydrologic models for Ontario, as well as other empirical relationships pertaining to flow estimation, with the support of GIS to provide various physiographic and climatic inputs. OFAT is a useful tool that effectively and efficiently manages spatial watershed databases and performs hydrologic analyses to support decisions related to water resources planning and management in Ontario.

The framework of OFAT can be found in the end of this chapter. In addition to the hydrological models, it should be noted that there are some other potential modelling components as shown in the framework (e.g., fisheries models). It is hoped that in the future OFAT can be used to support other ecological models that may require flow information.

Why Use OFAT?

"What are the flow regimes for a watershed of interest?" is a question frequently faced by engineers, biologists, river scientists, resource managers, planners, regulatory agencies, hydro, and forestry companies. Baseline flow information is needed to:

- design hydraulic structures such as culverts, bridges, dams, etc.
- protect or enhance fish habitat
- support an ecosystem approach to land/water management

Unfortunately, the question is usually difficult to answer because streamflow data is scarce for the majority of river systems in the world. The high costs to install/maintain hydrometric stations, particularly for those in underdeveloped or remote regions such as the northern part of the province of Ontario, contribute to the scarcity of flow information. In many cases, predictive hydrologic models are required to estimate flow regimes at an ungauged site.

A number of hydrologic models, based upon regional analysis of flow data at gauging stations in Ontario, have been developed to estimate various flow regimes for ungauged watersheds in Ontario. However, if a hydrologic model is used to support decision-making processes related to water resources planning and management, it cannot produce realistic results unless all parameters used in the model can be properly defined. Implementation of hydrologic models often requires dealing with large quantities of spatial data pertaining to a watershed (including climate, landforms, land cover, soil/geology, etc.) to determine model inputs. Preparation of model inputs can be laborious, repetitive, costly, and error prone if done manually. To effectively and efficiently manage various spatial watershed databases and perform hydrologic analyses, a system is needed that can estimate flow regimes based on the most updated watershed information. As a result, more comprehensive assessment of risks associated with alternate watershed management decisions can be made.

A GIS provides an efficient way to store, retrieve, analyze, and display a large volume of spatial data. Applications of GIS technology in the area of water resources have been steadily progressive over the past three decades. The use of GIS in hydrologic modelling leads to considerable time and cost savings when preparing modelling inputs such as climatic and physiographic parameters required by models.

The GIS-based OFAT application allows the efficient assessment of various flow regimes (e.g., low flows, flood flows, etc.) for a watershed of interest anywhere in Ontario. The flow information can be used to support diverse planning and management decisions related to watershed resources.

Who Should Use OFAT?

- water resources planners
- water resources managers
- water resources engineers
- riverine/watershed scientists and researchers
- information managers
- aquatic biologists
- instream flow developers
- instream flow regulators
- stakeholders
- field staff

How OFAT Works?

OFAT has been developed in ArcView GIS 3.2a (ESRI, 1996) with the Spatial Analyst Extension 2.0 (ESRI, 1996) loaded, by using the AVENUE programming language. OFAT is made up of two primary components: software and databases.

Software

The ArcView project file, *OFAT.apr*, contains the software to perform OFAT functions including:

- automatic watershed delineation,
- calculation of watershed parameters as well as summary of watershed information, and
- hydrologic modelling.

Flow information (e.g., flood flows, low flows, etc.) can be derived for a watershed anywhere in Ontario by using OFAT, after the watershed has been delineated and watershed parameters calculated. At present, OFAT contains a number of regional hydrological models and empirical relationships to generate flow information. Each model and relationship requires specific climate/physiographic inputs. The following lists five flow model categories currently included in OFAT. Each category contains a number of flow models:

1. Low Flow Prediction Models (LOF)
    - Isoline Method (MOEE, 1995)
    - Graphical Index Method (MOEE, 1995)
    - Statistical Index Method (MOEE, 1995)
    - Regression Method (MOEE, 1995)
2. Flood Prediction Models (HIF)
    - Index Flood Method (Moin & Shaw, 1985)
    - Index Flood Method With Expected Probability Adjustment (Moin & Shaw, 1985)
    - Primary Multiple Regression Method (Moin & Shaw, 1985)
    - Secondary Multiple Regression Method (Moin & Shaw, 1985)
    - Multiple Regression Method (MNR, 2000)
    - Dimensionless Flood Frequency Method (MNR, 2000)
    - Regional Flood Frequency Method (MNR, 2000)
    - Isoline Method (MNR, 2000)
3. Mean Annual Flow Prediction Model (MAF)
    - Isoline Method (Environment Canada, 1986)
4. Minimum Instream Flow Requirement Models (IFR)
    - Montana Method - October to March (Tennant, 1976)
    - Montana Method - April to September (Tennant, 1976)
5. Bankfull Discharge Prediction Model (BFQ)
    - Annable Bankfull Discharge Model (Annable, 1994)
    - Leopold Bankfull Discharge Model (Leopold *et al.*, 1964)
    - Dury Bankfull Discharge Model (Dury, 1973)

Databases

Databases required by and included in OFAT are as follows:

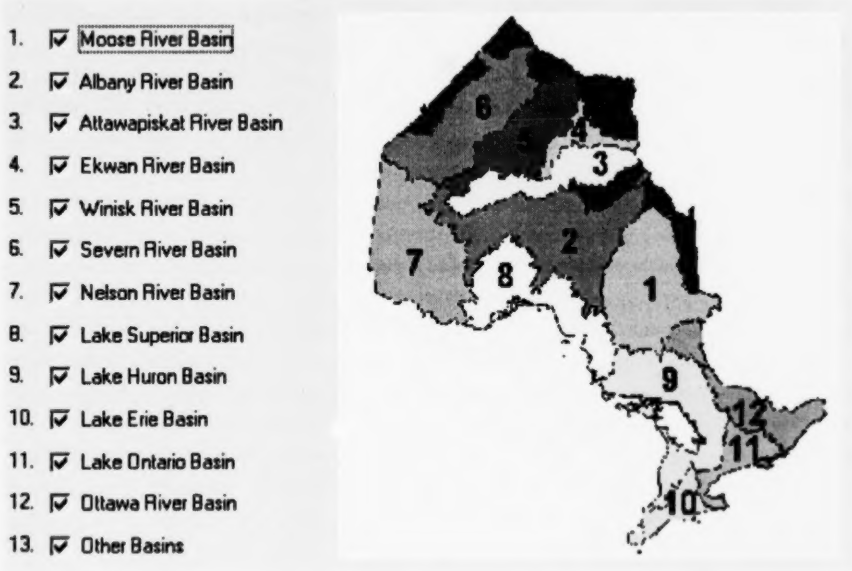
- Digital Elevation Models (DEMs) (created by MNR) based on 1:10,000 and 1:20,000 Ontario Digital Topographic Database (ODTD – formerly Ontario Basic Mapping, OBM) (MNR, 1996). Four different resolutions of DEM cell size have been created by MNR:
    - 10m*10m (southern Ontario only) (MNR, 2002)
    - 20m*20m – northern Ontario (MNR, 2002) and southern Ontario (created by the OFAT project)
    - 100m*100m (all of Ontario) (created by the OFAT project)
    - 1km*1km (all of Ontario) (created by the OFAT project)

  All the DEM databases contained in OFAT have been organized in provincial tertiary watersheds (e.g., 4LA, 4LB, etc.) except for 1km*1km DEMs which have been organized in the 13 major basins in Ontario (e.g., the Moose River Basin, the Lake Superior Basin, etc.);

✎ *Note: The DEMs of 10m*10m resolution for southern Ontario are not currently included in OFAT Version 1.0. This is because of issues related to the large file size and efficiency in data processing for the10m*10m DEMs organized in tertiary watersheds. To overcome these issues, a plan is underway to organize the 10m and 20m resolution DEMs into the provincial quaternary watersheds (e.g., 4LA-01, 4LA-02, etc.). Therefore, 10m*10m DEMs for southern Ontario will be included in a future upgraded version of OFAT.*

- 1km*1km DEM based on 1:250,000 NTS elevation data (Mackey *et al.*, 1994);
- Databases extracted from Natural Resource Values Information System (NRVIS), including rivers, lakes, wetlands, single-line waterflow, roads, etc. (MNR, 1997);
- DEM-related databases including flow direction, flow accumulation, and raster-based drainage network (created by the OFAT project);
- Databases extracted from the River Information Management System (RIMS) including the major basin boundaries, tertiary watershed boundaries, etc. (Moore and Chang, 1999);
- Ontario Land Cover Data Base with 25m*25m cell resolution (MNR, 1997);
- Soil Landscape of Canada at 1:1,000,000 scale, i.e., CANSIS (Agriculture and Agri-Food Canada, 1996);
- Ontario Land Inventory at 1:1,000,000 scale (MNR, 1997);
- Surficial Geology of Ontario at 1:1,000,000 scale (Perera *et al.*, 1996);
- Quaternary Geology of Ontario at 1:1,000,000 scale (MNDM, 1997);
- Runoff Curve Number (CN) databases with 25m*25m cell resolution, created by the OFAT project using the SCS method (SCS, 1972);
- GIS layers such as mean annual precipitation, which are created from the Canadian Daily Climate Data CD (Environment Canada, 2001);
- Maps that are digitized from the report entitled "Water Quantity Resources of Ontario" (MNR, 1984);
- Databases, maps, equations, tables, charts, and relationships that are digitized from reports entitled "Flood Regionalization for Ontario" (MNR, 2000), "Regionalization of Low Flow Characteristics" (MOEE, 1995), and "Canada/Ontario Flood Damage Reduction Program - Regional Flood Frequency Analysis for Ontario Streams" (Moin and Shaw, 1985); and
- Equations, tables, and relationships that are automated from existing Instream Flow Requirement (IFR) models and Bankfull Flow (BF) models.

Ontario has been divided into 13 major basins (as shown in the following map) to effectively and efficiently manage the OFAT databases.



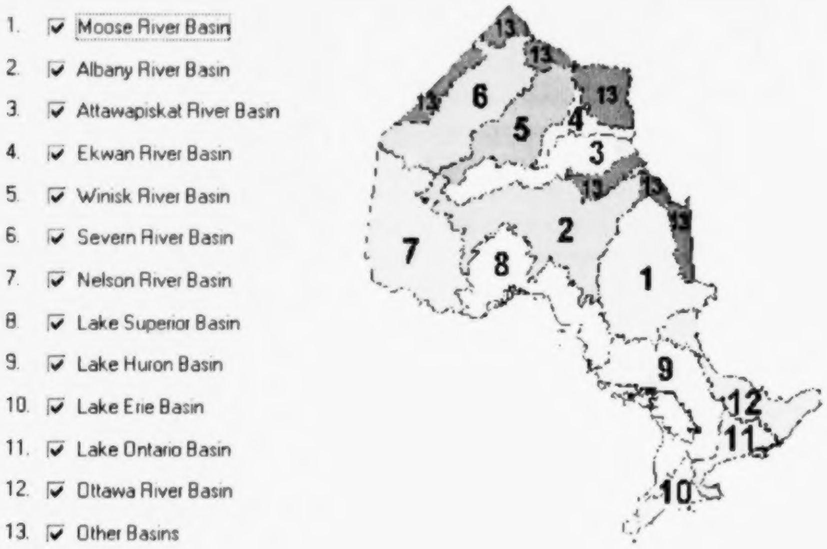
1. ☑ Moose River Basin
2. ☑ Albany River Basin
3. ☑ Attawapiskat River Basin
4. ☑ Ekwan River Basin
5. ☑ Winisk River Basin
6. ☑ Severn River Basin
7. ☑ Nelson River Basin
8. ☑ Lake Superior Basin
9. ☑ Lake Huron Basin
10. ☑ Lake Erie Basin
11. ☑ Lake Ontario Basin
12. ☑ Ottawa River Basin
13. ☑ Other Basins

What can you do with OFAT?

OFAT can be used to support the following watershed-related business areas:

- **Water management/planning** - Use OFAT in conjunction with other models to assist in deriving water allocation strategies (e.g., determining minimum flow requirements for fish habitat protection, recreation use, or water quality; hydropower peaking/ramping rate impact assessment; relations of flow scenario to water levels, etc.)
- **Fish habitat rehabilitation** - Use products/outputs from OFAT to assist in developing design criteria to protect or enhance fish habitat (e.g., fish spawning habitat enhancements via natural channel design).
- **River/valley segment classification systems** - OFAT would provide the hydrological component of systems presently being developed for classification of aquatic communities within rivers and streams in Ontario.
- **Water crossings design** - Use OFAT as a comparative tool to examine calculation methods used to determine opening size of water crossings such as culverts and bridges to ensure flow efficiency as well as fish passage.
- **Forest hydrology** - Use OFAT to generate hydrologic base for examining changes in local/regional hydrology as a result of forest disturbance.
- **Waterpower** - OFAT can be used to assist in estimating capacity of hydropower for potential hydro sites in Ontario.

Ontario has been divided into 13 major basins (as shown in the following map) to effectively and efficiently manage the OFAT databases.



1. ☑ Moose River Basin
2. ☑ Albany River Basin
3. ☑ Attawapiskat River Basin
4. ☑ Ekwan River Basin
5. ☑ Winisk River Basin
6. ☑ Severn River Basin
7. ☑ Nelson River Basin
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- **River/valley segment classification systems** - OFAT would provide the hydrological component of systems presently being developed for classification of aquatic communities within rivers and streams in Ontario.
- **Water crossings design** - Use OFAT as a comparative tool to examine calculation methods used to determine opening size of water crossings such as culverts and bridges to ensure flow efficiency as well as fish passage.
- **Forest hydrology** - Use OFAT to generate hydrologic base for examining changes in local/regional hydrology as a result of forest disturbance.
- **Waterpower** - OFAT can be used to assist in estimating capacity of hydropower for potential hydro sites in Ontario.

- **Environmental assessment** - OFAT can be used to assist in evaluating fish habitat based on stream behaviour and characteristics when conducting environmental assessment for proposed instream development projects.
- **Update/Development of models** - OFAT provides a framework to facilitate the update of existing hydrologic models and the development of new hydrologic models.

System Requirements

Hardware

- Pentium II processor or higher
- 256 MB RAM or more preferred, 128 MB RAM minimum
- OFAT databases are organized in the context of major basins. It is estimated that the total size of OFAT databases for all the thirteen basins in Ontario is about 40 GB (1GB ≅ 1,000 MB). However, the OFAT installation software provides users with the flexibility to select major basin(s) and DEMs of different cell size for which they would like to install the related databases on their hard drive. It is estimated that about 3 to 8 GB free hard disk space is required for the complete installation of a selected major basin, depending on its size. Disk space of 50 MB is required for OFAT software installation and an additional 400 MB system temporary space is required for running OFAT efficiently and smoothly.
- CD or DVD drive
- 17-inch or larger colour monitor preferred, 15-inch high-resolution colour monitor minimum

Software

- ArcView GIS version 3.2a or higher
- ArcView Spatial Analyst Extension 2.0 or higher
- Windows 95, 98, NT 4, 2000, or XP operating system

Where to Go for More Help

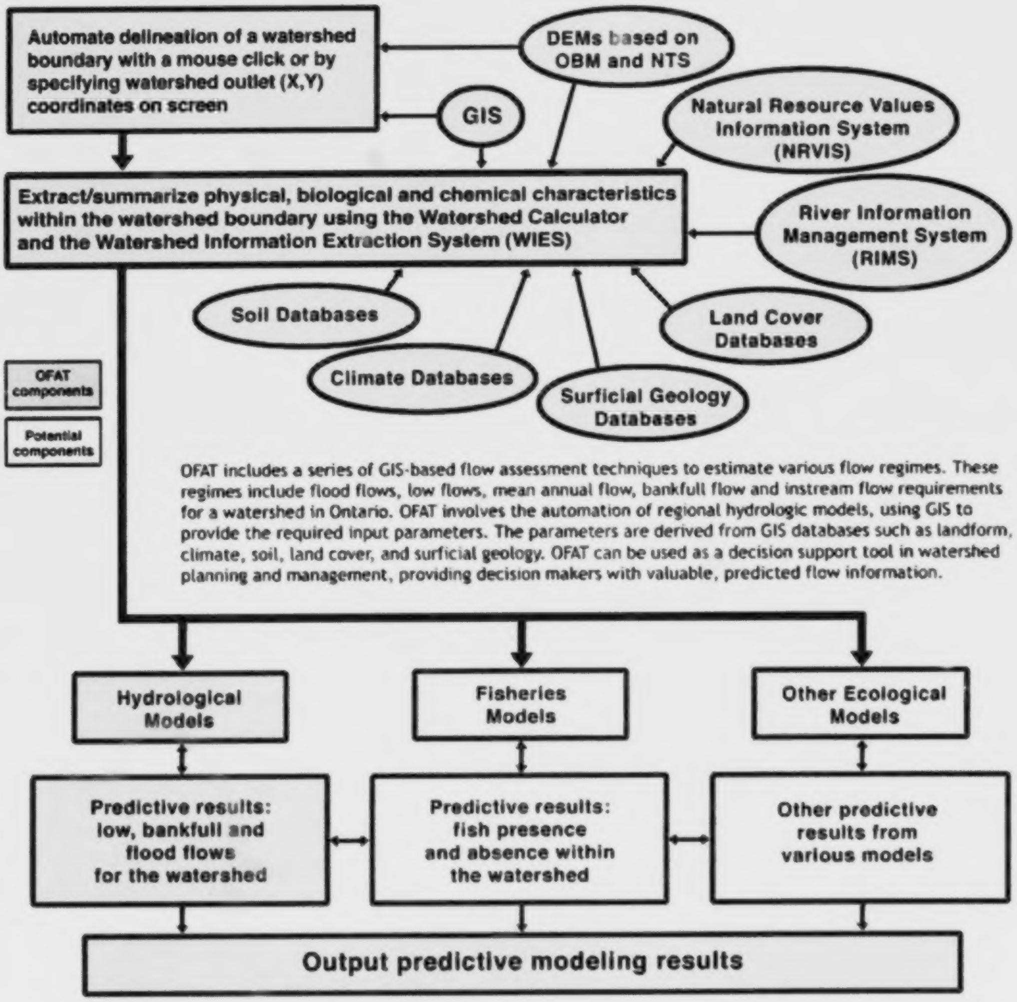
There are four different ways from which you can get help about using OFAT software and/or databases:

- You should read the User's Manual carefully for answers to questions you may have about using OFAT. You can print extra copies of the Manual, if needed. The electronic copy of this User's Manual is available in Adobe Acrobat Reader format (filename: *OFAT User's Manual.pdf*). This file can be found in the \OFAT_APP\Document folder on the OFAT Setup CD or on your hard drive after you have installed OFAT. If you do not have Adobe Acrobat Reader installed on your computer, run the Adobe Acrobat Reader 4.0 installation software (filename: *AR40ENG.exe*) found in the \OFAT_APP\Other\ folder on the OFAT Setup CD or on your hard drive after you have installed OFAT.
- You can use the OFAT Online Help system when you are running the software. The Windows-standard help system can be accessed by selecting the 'OFAT Help' item under the 'Help' pull down menu when OFAT is running.
- You can visit the following OFAT Internet and Intranet web sites to get the most updated information about OFAT, including news, upgrades, user discussion forum, etc.:

  Internet site:
  http://nesi.mnr.gov.on.ca
  Intranet site:
  http://mnronline.mnr.gov.on.ca/spectrasites/nesi/nesihomepage.cfm

- You can also reach the OFAT Development Team to get help by contacting:

  Dr. Chiadih Chang, OFAT Team Leader
  Northeast Science & Information
  Ministry of Natural Resources
  Highway 101 East, P.O. Bag 3020
  South Porcupine, Ontario
  Canada P0N 1H0
  Tel: (705) 235-1214 (9:00 a.m. – 4:30 p.m. EST, Monday-Friday)
  Fax: (705) 235-1251
  E-mail: chiadih.chang@mnr.gov.on.ca


Automate delineation of a watershed boundary with a mouse click or by specifying watershed outlet (X,Y) coordinates on screen
DEMs based on OBM and NTS
GIS
Natural Resource Values Information System (NRVIS)
Extract/summarize physical, biological and chemical characteristics within the watershed boundary using the Watershed Calculator and the Watershed Information Extraction System (WIES)
River Information Management System (RIMS)
Soil Databases
Land Cover Databases
Climate Databases
Surficial Geology Databases
OFAT components
Potential components
Hydrological Models
Fisheries Models
Other Ecological Models
Predictive results: low, bankfull and flood flows for the watershed
Predictive results: fish presence and absence within the watershed
Other predictive results from various models
Output predictive modeling results

OFAT includes a series of GIS-based flow assessment techniques to estimate various flow regimes. These regimes include flood flows, low flows, mean annual flow, bankfull flow and instream flow requirements for a watershed in Ontario. OFAT involves the automation of regional hydrologic models, using GIS to provide the required input parameters. The parameters are derived from GIS databases such as landform, climate, soil, land cover, and surficial geology. OFAT can be used as a decision support tool in watershed planning and management, providing decision makers with valuable, predicted flow information.

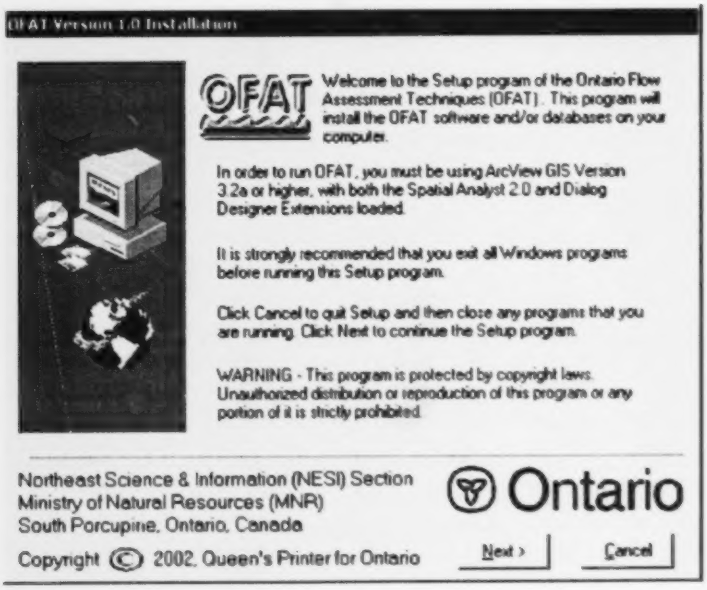
Ontario Flow Assessment Techniques (OFAT)

How to Install OFAT

The following steps show how to run the OFAT Setup program to install OFAT software and/or databases:

1. If Windows is not running, start it now.

2. Insert the OFAT Setup CD into your CD-ROM drive. The OFAT Setup program will start automatically and the following welcome dialog box will appear. Go to Step 6 to continue the OFAT installation. Otherwise, if you do not see the following dialog box, proceed to Step 3 to continue.



Welcome to the Setup program of the Ontario Flow Assessment Techniques (OFAT). This program will install the OFAT software and/or databases on your computer.

In order to run OFAT, you must be using ArcView GIS Version 3.2a or higher, with both the Spatial Analyst 2.0 and Dialog Designer Extensions loaded.

It is strongly recommended that you exit all Windows programs before running this Setup program.

Click Cancel to quit Setup and then close any programs that you are running. Click Next to continue the Setup program.

WARNING - This program is protected by copyright laws. Unauthorized distribution or reproduction of this program or any portion of it is strictly prohibited.

Northeast Science & Information (NESI) Section
Ministry of Natural Resources (MNR)
South Porcupine, Ontario, Canada
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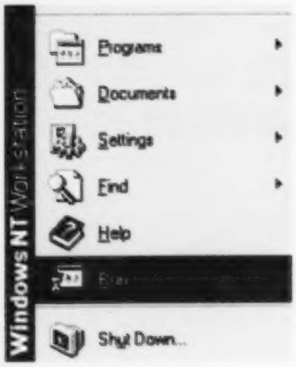
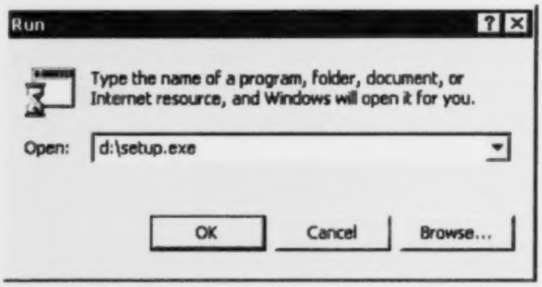
3. Click the 'Start' button **Start** on the Windows taskbar. Windows will open the following 'Start' menu. Select the 'Run' menu item.



4. Windows will open the following 'Run' dialog box. Type the drive letter (e.g., *d:*) of the CD-ROM containing the OFAT Setup CD followed by *\setup.exe*. To search for the *setup.exe* file location, click 'Browse'.

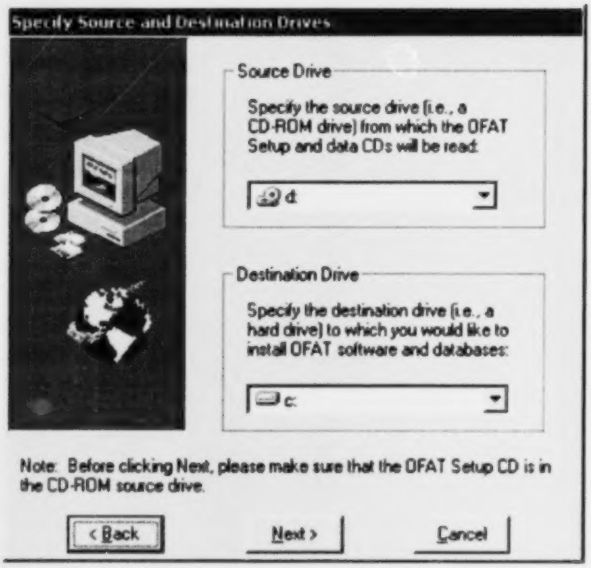


Type the name of a program, folder, document, or Internet resource, and Windows will open it for you.

Open: d:\setup.exe

5. Click 'OK'. Windows will run the OFAT Setup program. The welcome dialog box as shown in Step 2 will appear.

6. Click 'Next'. The following dialog box will appear. You are asked to specify a source drive (i.e., a CD-ROM drive) from which the OFAT Setup and data CDs will be read. You are also asked to specify a destination drive (i.e., a hard drive) to which you would like to install OFAT software and databases.



Specify the source drive (i.e., a CD-ROM drive) from which the OFAT Setup and data CDs will be read:

d:

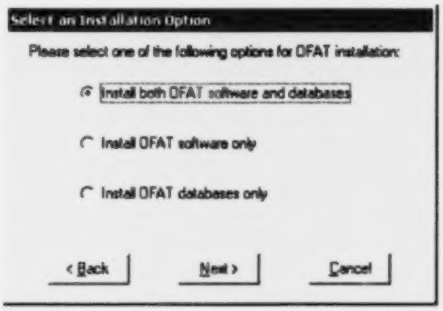
Specify the destination drive (i.e., a hard drive) to which you would like to install OFAT software and databases:

c:

Note: Before clicking Next, please make sure that the OFAT Setup CD is in the CD-ROM source drive.

7. Click 'Next'. The following menu will appear and will ask you to select one of the following options for OFAT installation:
    - Install both OFAT software and databases
    - Install OFAT software only
    - Install OFAT databases only

   The second and third installation options will only be available for selection if OFAT has previously been installed on the computer. If the second option is selected (i.e., "Install OFAT software only"), by clicking 'Next', the Setup program will skip step 8 and go to step 9 directly.



Select an Installation Option

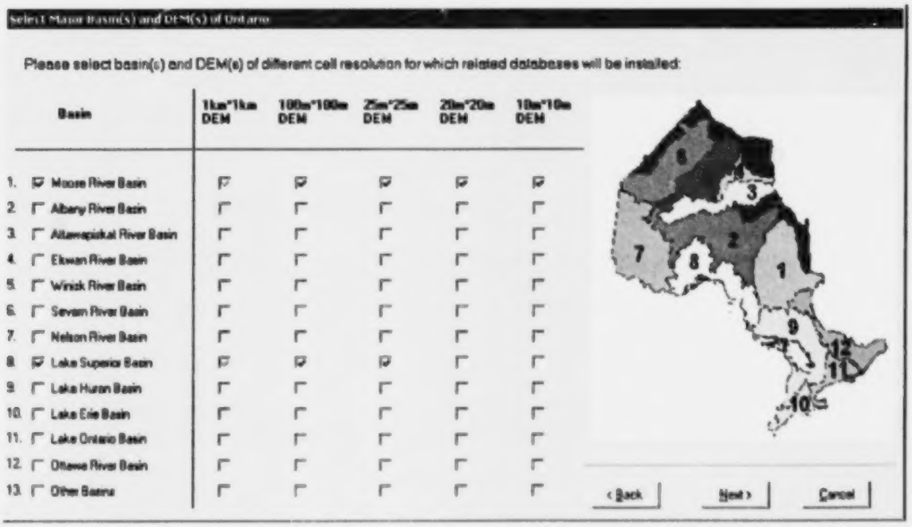
Please select one of the following options for OFAT installation:

● Install both OFAT software and databases

○ Install OFAT software only

○ Install OFAT databases only

8. Click 'Next'. The following dialog will appear that asks you to select major basin(s) of Ontario and DEMs of different cell resolutions, for which related databases will be installed on the destination drive of the computer. For example, the Moose River Basin and the Lake Superior Basin as well as available DEMs for the two selected basins are checked in the dialog box below. Note that as soon as a basin is selected, the checkboxes will be selected for DEMs available for that basin. You can select or unselect the checkboxes as you wish except the checkbox of the 1km*1km DEM, which will always remain selected. After you have made your selections, click 'Next'.



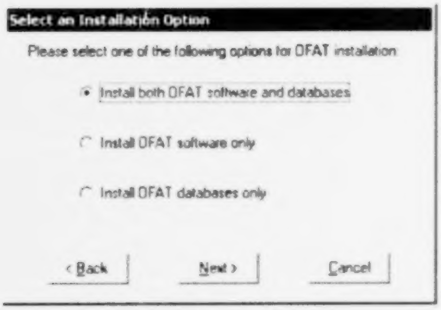
Select Major Basin(s) and DEM(s) of Ontario

Please select basin(s) and DEM(s) of different cell resolution for which related databases will be installed:

Basin	1km*1km DEM	100m*100m DEM	25m*25m DEM	20m*20m DEM	10m*10m DEM
1. ☑ Moose River Basin	☑	☑	☑	☑	☑
2. ☐ Albany River Basin	☐	☐	☐	☐	☐
3. ☐ Attawapiskat River Basin	☐	☐	☐	☐	☐
4. ☐ Ekwan River Basin	☐	☐	☐	☐	☐
5. ☐ Winisk River Basin	☐	☐	☐	☐	☐
6. ☐ Severn River Basin	☐	☐	☐	☐	☐
7. ☐ Nelson River Basin	☐	☐	☐	☐	☐
8. ☑ Lake Superior Basin	☑	☑	☑	☐	☐
9. ☐ Lake Huron Basin	☐	☐	☐	☐	☐
10. ☐ Lake Erie Basin	☐	☐	☐	☐	☐
11. ☐ Lake Ontario Basin	☐	☐	☐	☐	☐
12. ☐ Ottawa River Basin	☐	☐	☐	☐	☐
13. ☐ Other Basins	☐	☐	☐	☐	☐

7. Click 'Next'. The following menu will appear and will ask you to select one of the following options for OFAT installation:
    - Install both OFAT software and databases
    - Install OFAT software only
    - Install OFAT databases only

   The second and third installation options will only be available for selection if OFAT has previously been installed on the computer. If the second option is selected (i.e., "Install OFAT software only"), by clicking 'Next', the Setup program will skip step 8 and go to step 9 directly.



Select an Installation Option

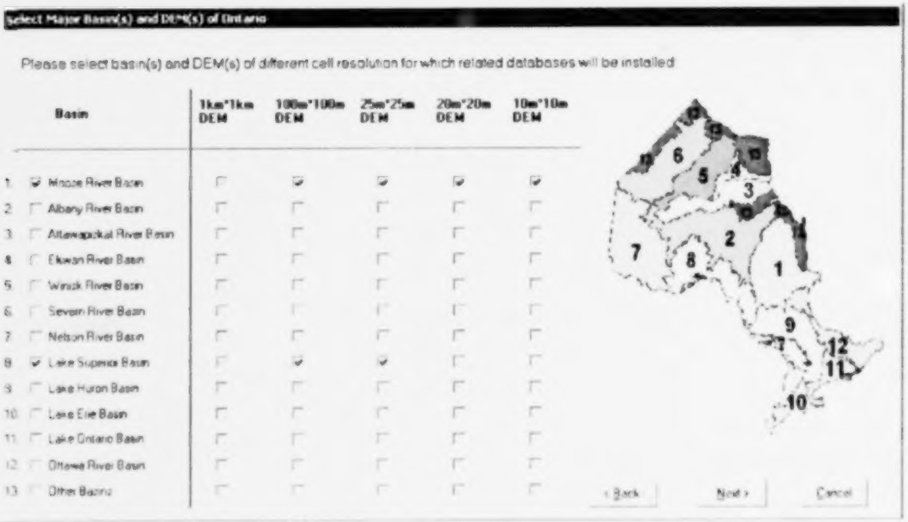
Please select one of the following options for OFAT installation

● Install both OFAT software and databases

○ Install OFAT software only

○ Install OFAT databases only

8. Click 'Next'. The following dialog will appear that asks you to select major basin(s) of Ontario and DEMs of different cell resolutions, for which related databases will be installed on the destination drive of the computer. For example, the Moose River Basin and the Lake Superior Basin as well as available DEMs for the two selected basins are checked in the dialog box below. Note that as soon as a basin is selected, the checkboxes will be selected for DEMs available for that basin. You can select or unselect the checkboxes as you wish except the checkbox of the 1km*1km DEM, which will always remain selected. After you have made your selections, click 'Next'.

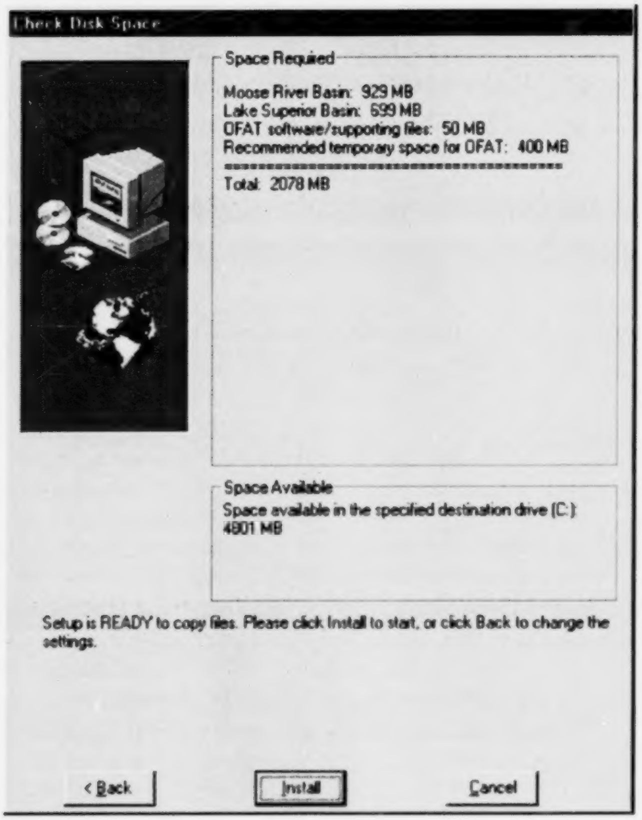


Select Major Basin(s) and DEM(s) of Ontario

Please select basin(s) and DEM(s) of different cell resolution for which related databases will be installed

	Basin	1km*1km DEM	100m*100m DEM	25m*25m DEM	20m*20m DEM	10m*10m DEM
1.	☑ Moose River Basin	☐	☑	☑	☑	☑
2.	☐ Albany River Basin	☐	☐	☐	☐	☐
3.	☐ Attawapiskat River Basin	☐	☐	☐	☐	☐
4.	☐ Ekwan River Basin	☐	☐	☐	☐	☐
5.	☐ Winisk River Basin	☐	☐	☐	☐	☐
6.	☐ Severn River Basin	☐	☐	☐	☐	☐
7.	☐ Nelson River Basin	☐	☐	☐	☐	☐
8.	☑ Lake Superior Basin	☐	☑	☑	☐	☐
9.	☐ Lake Huron Basin	☐	☐	☐	☐	☐
10.	☐ Lake Erie Basin	☐	☐	☐	☐	☐
11.	☐ Lake Ontario Basin	☐	☐	☐	☐	☐
12.	☐ Ottawa River Basin	☐	☐	☐	☐	☐
13.	☐ Other Basins	☐	☐	☐	☐	☐

9. The following message will appear showing a summary of required and available disk space. If the destination drive of the computer does not have enough space to install OFAT, the 'Install' button will be dimmed out. In this case, you can click 'Back' to change your installation settings such as the destination drive, major basin, and DEM selections.



Space Required

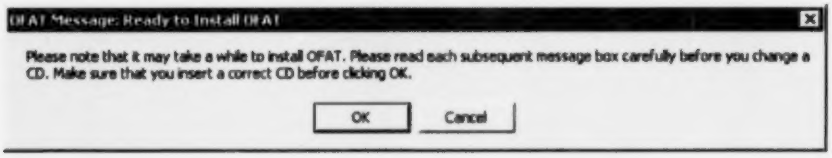
```
Moose River Basin:  929 MB
Lake Superior Basin:  699 MB
OFAT software/supporting files:  50 MB
Recommended temporary space for OFAT:  400 MB
==========================================
Total:  2078 MB
```

Space Available

Space available in the specified destination drive (C:):
4801 MB

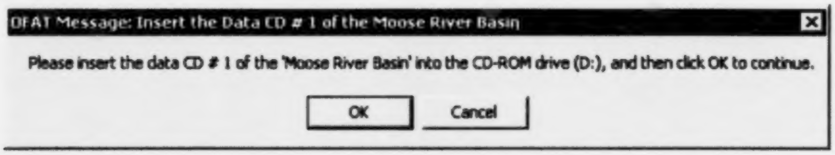
Setup is READY to copy files. Please click Install to start, or click Back to change the settings.

10. Click 'Install'. The following 'Ready to Install OFAT' message box will appear. At this point, OFAT Setup program has gathered all the necessary information for installation.



Please note that it may take a while to install OFAT. Please read each subsequent message box carefully before you change a CD. Make sure that you insert a correct CD before clicking OK.

11. Click 'OK'. The OFAT Setup program will start copying files from the CD-ROM drive to the specified destination hard drive. Once all the files contained in the inserted CD have been copied to the destination drive, the following message box, or similar, will appear and ask you to insert a specific data CD of a selected basin into CD-ROM drive.



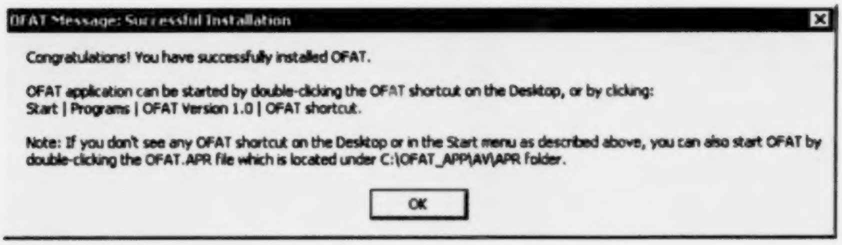
OFAT Message: Insert the Data CD # 1 of the Moose River Basin

Please insert the data CD # 1 of the 'Moose River Basin' into the CD-ROM drive (D:), and then click OK to continue.

✎ ***Note**: Please make sure that you insert the correct data CD of a selected basin into CD-ROM drive in the order of CD #1, #2, #3...*

12. Click 'OK' after you have inserted the correct data CD of the basin shown in the message box in Step 11 into the CD-ROM drive. Repeat this step until all the data CDs for each of the selected basins have been copied to the destination drive. Please be patient. The copying process will take some time to complete.

13. Once all the data CDs of every selected basin have been successfully copied to the destination drive, the following message box will appear. This message will show you how to start OFAT software.



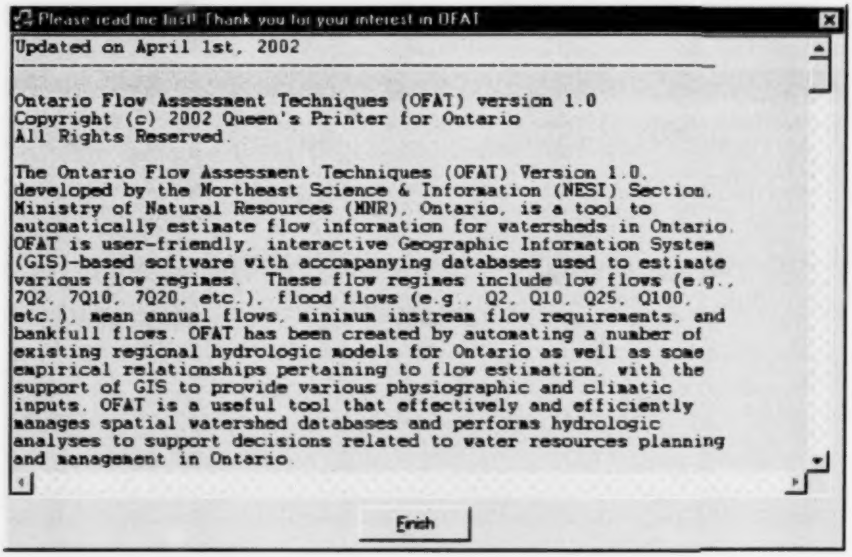
OFAT Message: Successful Installation

Congratulations! You have successfully installed OFAT.

OFAT application can be started by double-clicking the OFAT shortcut on the Desktop, or by clicking:
Start | Programs | OFAT Version 1.0 | OFAT shortcut.

Note: If you don't see any OFAT shortcut on the Desktop or in the Start menu as described above, you can also start OFAT by double-clicking the OFAT.APR file which is located under C:\OFAT_APP\AV\APR folder.

14. Click 'OK'. The 'Read Me' dialog box will appear containing the most up-to-date information about OFAT. Please read the entire document carefully.



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Updated on April 1st, 2002
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Ontario Flow Assessment Techniques (OFAT) version 1.0
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The Ontario Flow Assessment Techniques (OFAT) Version 1.0,
developed by the Northeast Science & Information (NESI) Section,
Ministry of Natural Resources (MNR), Ontario, is a tool to
automatically estimate flow information for watersheds in Ontario.
OFAT is user-friendly, interactive Geographic Information System
(GIS)-based software with accompanying databases used to estimate
various flow regimes.  These flow regimes include low flows (e.g.,
7Q2, 7Q10, 7Q20, etc.), flood flows (e.g., Q2, Q10, Q25, Q100,
etc.), mean annual flows, minimum instream flow requirements, and
bankfull flows. OFAT has been created by automating a number of
existing regional hydrologic models for Ontario as well as some
empirical relationships pertaining to flow estimation, with the
support of GIS to provide various physiographic and climatic
inputs. OFAT is a useful tool that effectively and efficiently
manages spatial watershed databases and performs hydrologic
analyses to support decisions related to water resources planning
and management in Ontario.
```

15. Click 'Finish'. You have now finished the OFAT installation. An OFAT shortcut will automatically be created on your Desktop. To start OFAT, double-click on the shortcut icon. In addition, an OFAT program folder will be created allowing you to start OFAT through the following steps:

    1) Click the 'Start' button on the Windows taskbar.

    2) Select 'Programs' from the 'Start' menu.

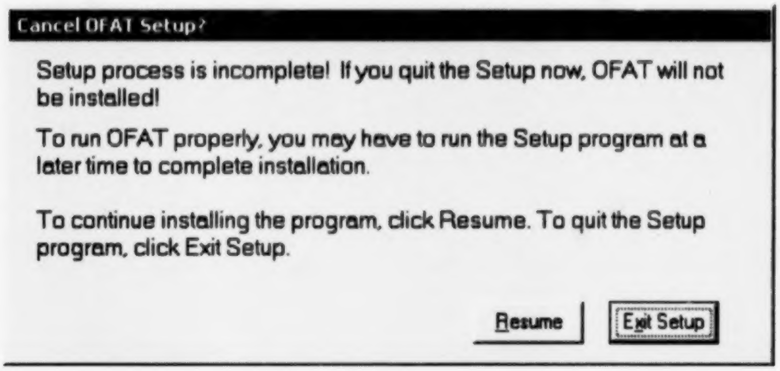
    3) Select 'OFAT Version 1.0' from the 'Programs' folder.

    4) Click 'OFAT' option from the 'OFAT Version 1.0' folder.

After the installation is finished, you will find two folders created in the specified destination drive: 'OFAT_APP' and 'OFAT_DAT'. The 'OFAT_APP' folder contains OFAT software and other supporting files, while the 'OFAT_DAT' folder contains databases of the basin(s) you chose to install.

- ***Note**: In the process of running the OFAT Setup program, you may click 'Back' on the current dialog box to return to the previous dialog box so that you can change Setup settings and/or selections.*

- ***Note**: While running the OFAT Setup program, you may click 'Cancel' in the current dialog box to interrupt the installation. When 'Cancel' is clicked the following message box will appear. If you click 'Resume', the Setup program will return to the previous dialog box. If you click 'Exit Setup', the installation will end immediately. In this case, the Setup process is incomplete. Although some of the OFAT folders/files may have already been copied to the destination drive, you will have to run the Setup program again at a later time to complete installation, enabling OFAT to run properly.*



Setup process is incomplete! If you quit the Setup now, OFAT will not be installed!

To run OFAT properly, you may have to run the Setup program at a later time to complete installation.

To continue installing the program, click Resume. To quit the Setup program, click Exit Setup.

Getting Started: The OFAT Way

In this chapter you will find out how to:

- start OFAT
- run an OFAT example
- exit OFAT

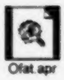
The following information is a basic overview of the OFAT process for delineating watersheds, deriving/summarizing watershed information, and calculating various flows. For more detailed information on specific OFAT functions, see the appropriate chapter.

The exercises in this chapter are intended to lead you through the major functions of OFAT. Each exercise builds on the previous one, so it is important to follow them in order. This will ensure that you learn all the basic functions that OFAT provides.

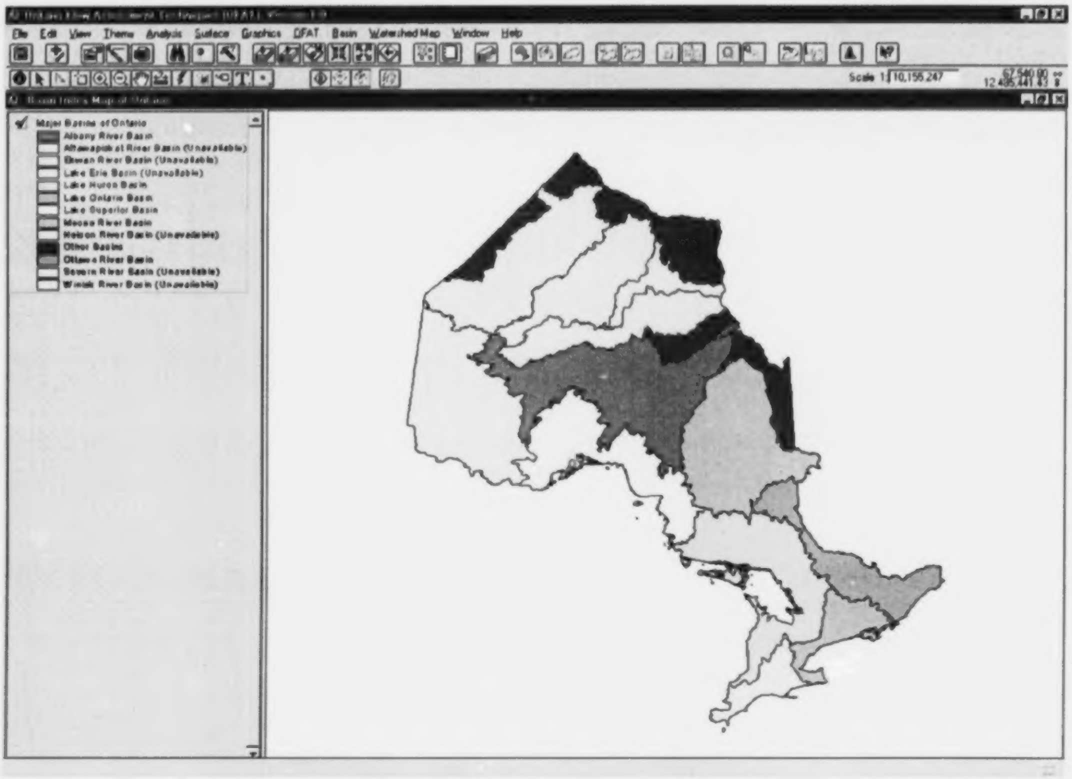
✎ ***Note**: The database of the Moose River Basin has been chosen for these exercises. However, if you have not loaded the data for this basin, data for any other OFAT major basin can be used.*

Starting OFAT

Double clicking the OFAT icon on your desktop will open ArcView and start the OFAT application.



A welcome window will appear. After a few seconds, it will close and the 'Basin Index Map of Ontario' will appear. This map allows you to select a major basin. Basins available for selection are colour coded and named within the table of contents. If the database associated with a basin is not currently installed, the basin will be coloured grey and will not be available for selection.


File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Scale 1:10,155,247
Major Basins of Ontario
Albany River Basin
Attawapiskat River Basin (Unavailable)
Ekwan River Basin (Unavailable)
Lake Erie Basin (Unavailable)
Lake Huron Basin
Lake Ontario Basin
Lake Superior Basin
Moose River Basin
Nelson River Basin (Unavailable)
Other Basins
Ottawa River Basin
Severn River Basin (Unavailable)
Winisk River Basin (Unavailable)

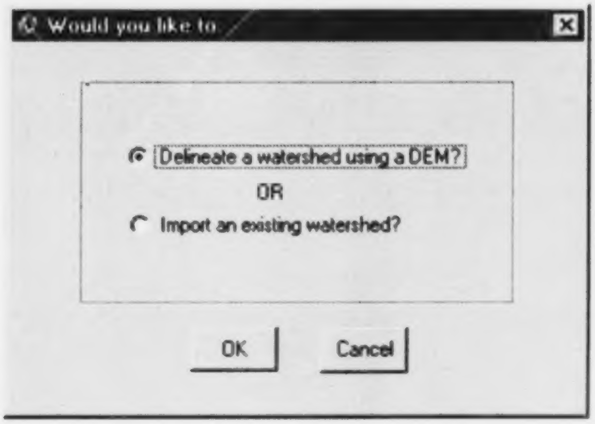
Quick Start: An Example

Selecting a Basin

With the tool selected on the toolbar, place your cursor on the major basin of interest and click to select.

Delineating or Importing a Watershed?

Once a major basin is selected the following dialog box appears:



Would you like to

● Delineate a watershed using a DEM?

OR

○ Import an existing watershed?

Select an option using the radio buttons and press 'OK'.

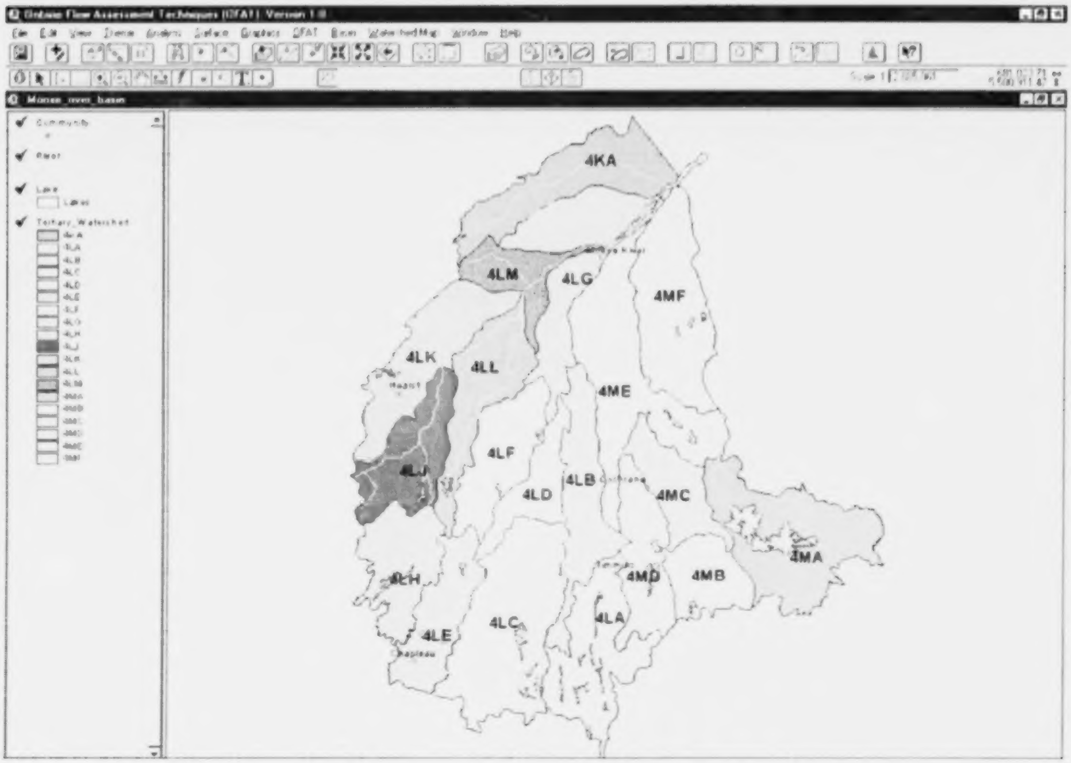
If the 'Delineate a watershed using a DEM?' option is selected, the tertiary watershed index map will be displayed. This map contains more detailed geographic information that will allow the user to narrow down the area of interest. The name of the selected major basin will be shown in the title of the map.

If the 'Import an existing watershed?' option is selected, it will only allow for WIES to run. Using WIES will be reviewed later in this chapter.

For this example, the 'Delineate a watershed using a DEM?' option has been selected. This option leads to a map of the selected major basin that has been divided into tertiary watersheds.

Selecting a Tertiary Watershed

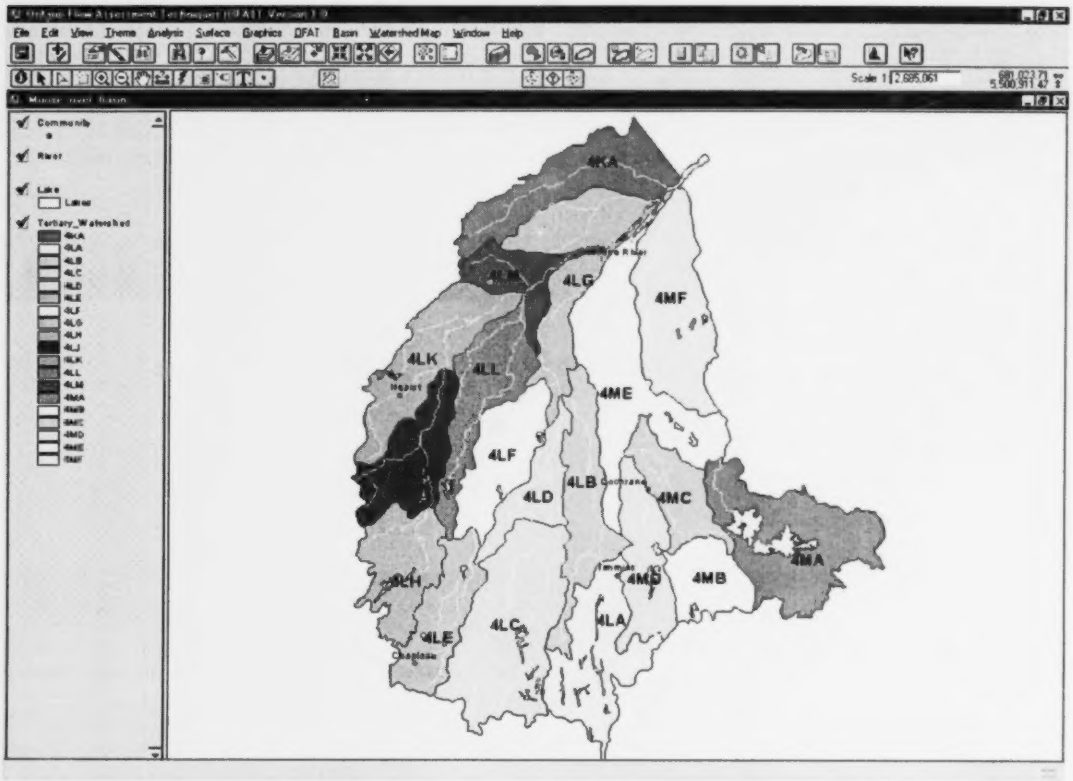
The displayed map will allow the selection of a tertiary watershed in order to narrow down the area of interest.


Ontario Flow Assessment Techniques (OFAT) Version 1.0
4KA
4LM
4LG
4MF
4LK
4LL
4ME
4LF
4LJ
4LB
4LD
4MC
4MA
4LH
4MD
4MB
4LA
4LC
4LE
Chapleau

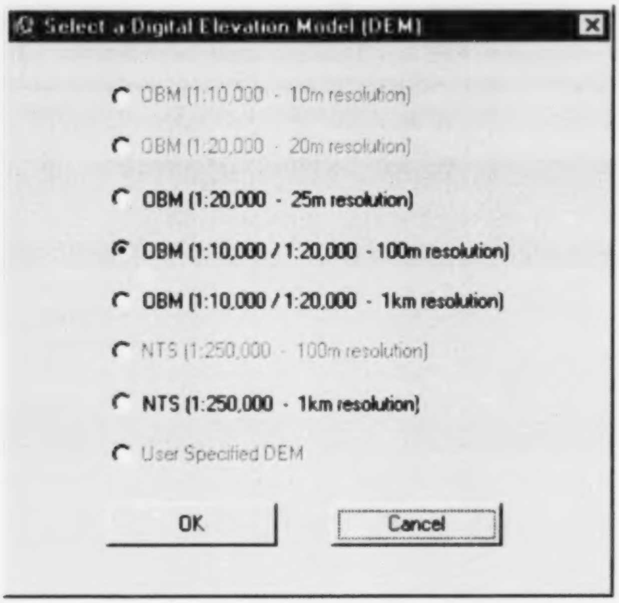
With the tool on the toolbar selected, place the cursor on the tertiary watershed of interest and click to select. You will then be prompted to select a DEM to be used for delineating a watershed.

Selecting a Tertiary Watershed

The displayed map will allow the selection of a tertiary watershed in order to narrow down the area of interest.


Ontario Flow Assessment Techniques (OFAT) Version 1.0
File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Scale 1: 2,685,061
680,023.71
5,500,911.47
Moose River Basin
Community
River
Lake
Lakes
Tertiary_Watershed
4KA
4LA
4LB
4LC
4LD
4LE
4LF
4LG
4LH
4LJ
4LK
4LL
4LM
4MA
4MB
4MC
4MD
4ME
4MF
4KA
4LM
4LG
4MF
4LK
4LL
Hearst
4ME
4LF
4LB
Cochrane
4MC
4LD
4MA
4LH
Timmins
4MD
4MB
4LC
4LA
4LE
Chapleau

With the ⊕ tool on the toolbar selected, place the cursor on the tertiary watershed of interest and click to select. You will then be prompted to select a DEM to be used for delineating a watershed.



Select a Digital Elevation Model (DEM)

○ OBM (1:10,000 - 10m resolution)

○ OBM (1:20,000 - 20m resolution)

○ OBM (1:20,000 - 25m resolution)

● OBM (1:10,000 / 1:20,000 - 100m resolution)

○ OBM (1:10,000 / 1:20,000 - 1km resolution)

○ NTS (1:250,000 - 100m resolution)

○ NTS (1:250,000 - 1km resolution)

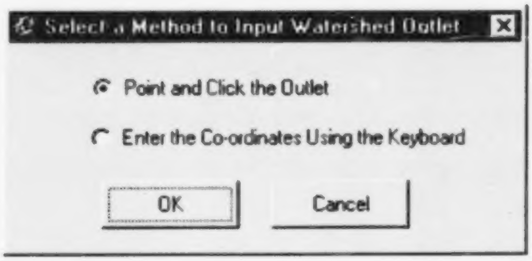
○ User Specified DEM

✎ ***Note**: In general, the larger the watershed you want to delineate, the coarser the resolution of DEM you choose. Finer resolution DEMs generally require longer processing time and larger temporary disk space.*

The DEMs currently available will be active and selectable. Select a DEM and click 'OK'.

Specifying a Watershed Outlet

You will be prompted to select a method for identifying the location of the watershed outlet.



Select a Method to Input Watershed Outlet

● Point and Click the Outlet

○ Enter the Co-ordinates Using the Keyboard

The 'Point and Click the Outlet' option allows the user to select a watershed outlet using the mouse.

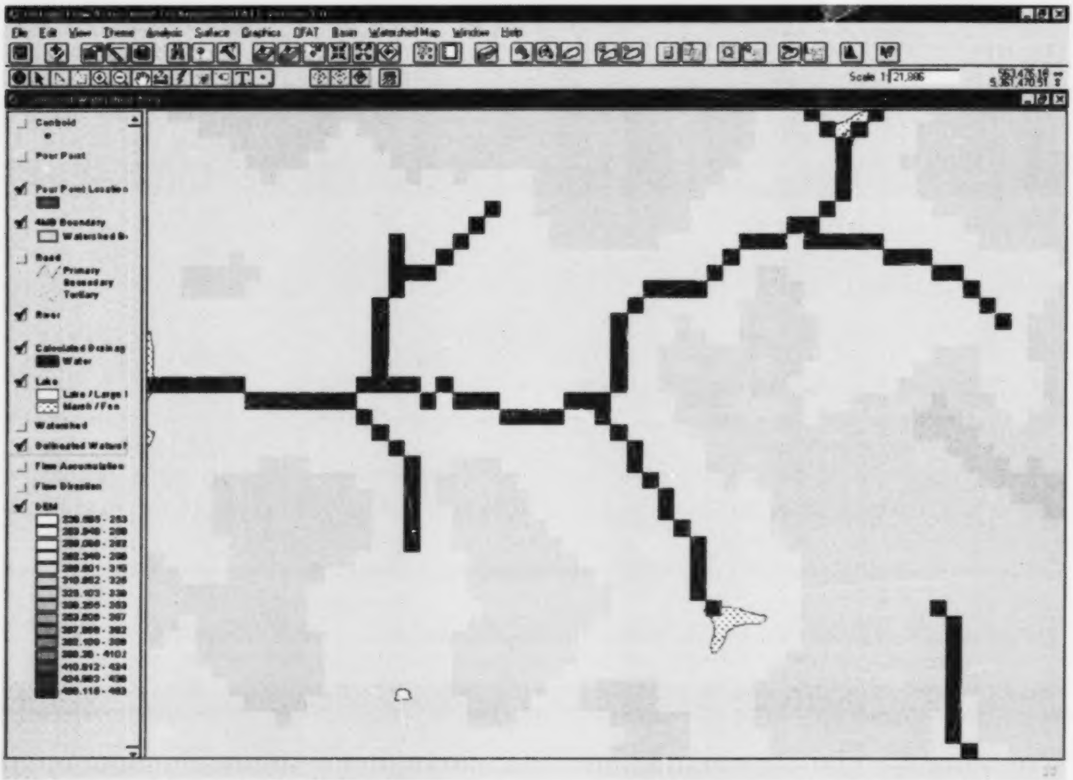
The 'Enter the Co-ordinates Using the Keyboard' option allows the user to enter the easting (X) and northing (Y) of the outlet point. These co-ordinates must be in UTM NAD 83 CNT projection.

For this example, select the 'Point and Click the Outlet' option and press 'OK'.

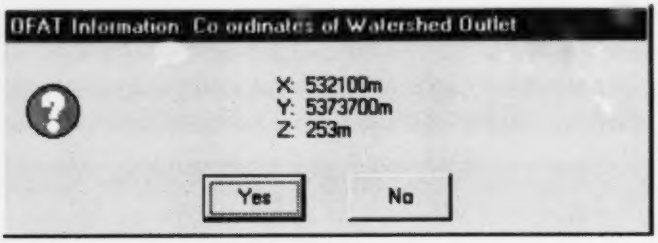
Delineating the Watershed

The 'Selected Watershed Area' will appear and the ◉ tool will become active. The initial 'Selected Watershed Area' shows the whole selected tertiary watershed within the viewing area.

It is recommended that the map be zoomed into the area of interest. This will allow the watershed outlet to be identified with relative ease.


File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Centroid
Pour Point
Pour Point Location
Road
Primary
Secondary
Tertiary
River
Calculated Drainage
Water
Lake
Marsh / Fen
Watershed
Delineated Watershed
Flow Accumulation
Flow Direction
DEM

In the 'Selected Watershed Area', the blue blocked lines represent the raster-based drainage network that was created using the selected DEM. The network lines should generally correspond to the river lines represented in the vector stream data, which are symbolized using a thin light blue line. It is important that the raster-based drainage lines be used to identify a watershed outlet. When a point is selected, a message box will appear giving the UTM easting (X) and northing (Y) co-ordinates, along with the elevation (Z) for the watershed outlet.



OFAT Information: Co-ordinates of Watershed Outlet

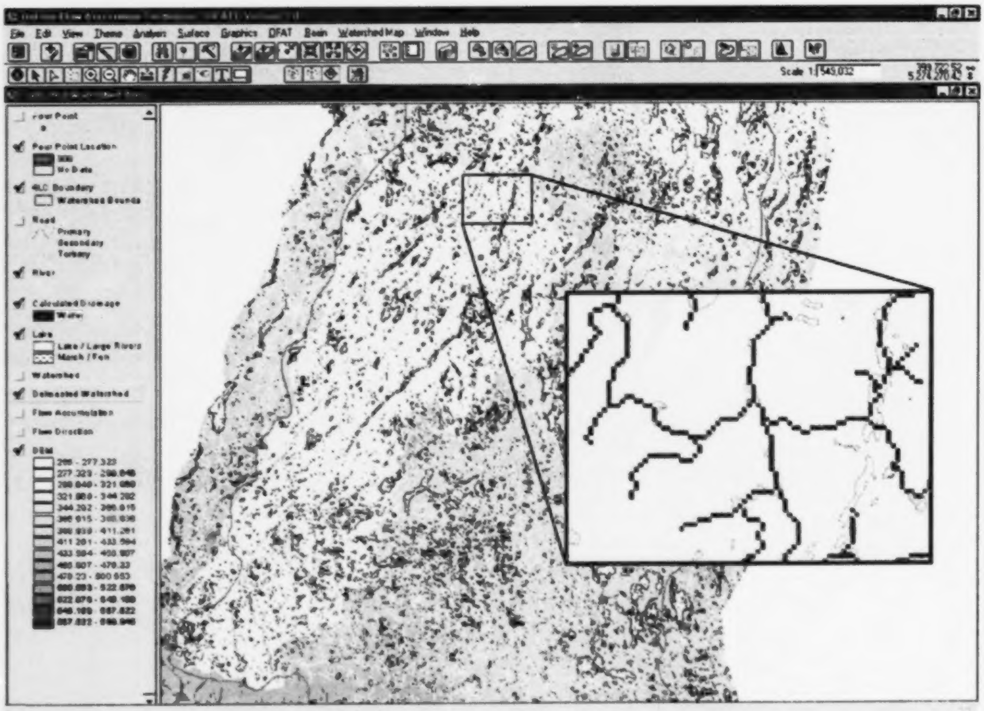
X: 532100m
Y: 5373700m
Z: 253m

Click 'Yes' to continue if the selected outlet is on the point of interest. Clicking 'No' will allow the selection of another point.

✎ *Note*: *If the watershed outlet you have selected is on the main channel and involves the merging of upstream tertiary watersheds, a warning message will appear asking if you would like to continue. For this example, please select 'No'. This option will be explained in the following chapter.*

The program will then delineate the watershed upstream from the selected outlet and add the watershed boundary to the 'Selected Watershed Area' map. The 'red square' on the raster-based drainage line represents the outlet (pour point) of the delineated watershed and the green area represents the spatial extent of the delineated watershed.

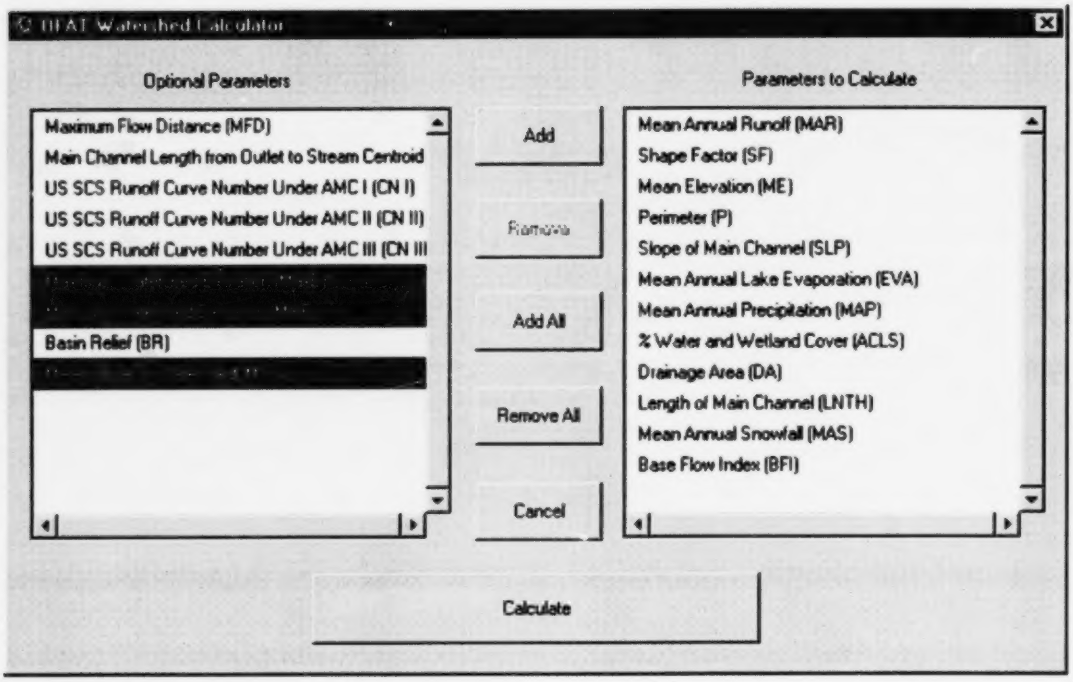
✎ ***Note:*** *For colour illustrations, please refer to the electronic copy of this manual (filename: OFAT User's Manual.pdf)*



File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Pour Point
Pour Point Location
No Data
Boundary
Watershed Bounds
Road
Primary
Secondary
Tertiary
River
Calculated Drainage
Water
Lake
Lake / Large Rivers
Marsh / Fen
Watershed
Delineated Watershed
Flow Accumulation
Flow Direction
DEM

Calculating Watershed Parameters

From this point, the 'Watershed Calculator' button will become active, allowing access to the Calculator interface. This function will calculate selected parameters of the delineated watershed.



Optional Parameters

- Maximum Flow Distance (MFD)
- Main Channel Length from Outlet to Stream Centroid
- US SCS Runoff Curve Number Under AMC I (CN I)
- US SCS Runoff Curve Number Under AMC II (CN II)
- US SCS Runoff Curve Number Under AMC III (CN III
- [illegible]
- Basin Relief (BR)
- [illegible]

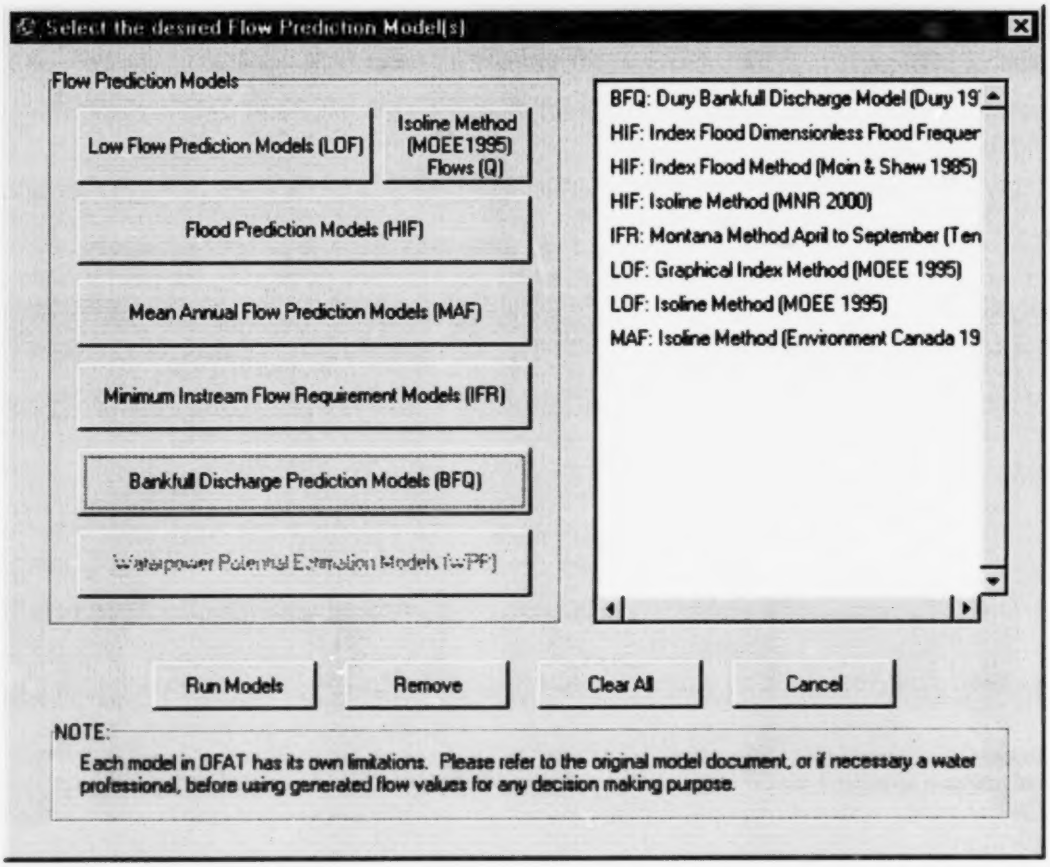
Parameters to Calculate

- Mean Annual Runoff (MAR)
- Shape Factor (SF)
- Mean Elevation (ME)
- Perimeter (P)
- Slope of Main Channel (SLP)
- Mean Annual Lake Evaporation (EVA)
- Mean Annual Precipitation (MAP)
- % Water and Wetland Cover (ACLS)
- Drainage Area (DA)
- Length of Main Channel (LNTH)
- Mean Annual Snowfall (MAS)
- Base Flow Index (BFI)

The items from the 'Parameters to Calculate' list are required to run flow models currently in OFAT. Any item from the 'Optional Parameters' list can be added to the 'Parameters to Calculate' list by selecting it from the list on the left, then clicking the 'Add' button. This will add the parameter to the 'Parameters to Calculate' list. To remove an added optional parameter from the 'Parameters to Calculate' list, select it and click the 'Remove' button. To run the calculations, click the 'Calculate' button. The selected parameters will be calculated and the results will appear in the 'Watershed Calculator Results' window (not shown). Click 'OK' on the window to close it.

Selecting and Running Models

After the watershed parameters are calculated, the 'Flow Prediction Models' button Q will become active and the 'Flow Prediction Models' interface can be accessed. The interface allows the selection of flow models from five available categories.


Select the desired Flow Prediction Model(s)
Flow Prediction Models
Low Flow Prediction Models (LOF)
Isoline Method (MOEE1995) Flows (Q)
Flood Prediction Models (HIF)
Mean Annual Flow Prediction Models (MAF)
Minimum Instream Flow Requirement Models (IFR)
Bankfull Discharge Prediction Models (BFQ)
Waterpower Potential Estimation Models (WPP)
Run Models
Remove
Clear All
Cancel

BFQ: Dury Bankfull Discharge Model (Dury 19
HIF: Index Flood Dimensionless Flood Frequer
HIF: Index Flood Method (Moin & Shaw 1985)
HIF: Isoline Method (MNR 2000)
IFR: Montana Method April to September (Ten
LOF: Graphical Index Method (MOEE 1995)
LOF: Isoline Method (MOEE 1995)
MAF: Isoline Method (Environment Canada 19

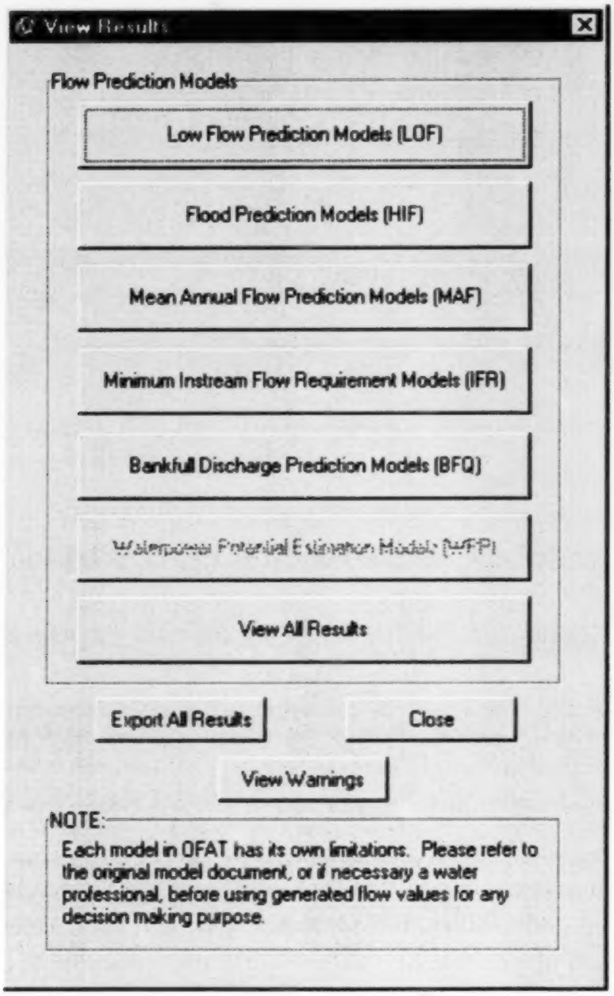
NOTE:
Each model in OFAT has its own limitations. Please refer to the original model document, or if necessary a water professional, before using generated flow values for any decision making purpose.

Clicking on the desired model category (e.g., Bankfull Discharge Prediction Models) will open the corresponding model selection window (not shown). Within a model selection window, select the models of interest and click 'OK'. This will add the models to the list on the 'Flow Prediction Models' interface above.

If a model needs to be removed from the list, select the model and click the 'Remove' button. If all models need to be removed, click 'Clear All'. Once all desired models have been added to the list, click the 'Run Models' button. This will calculate the flow values of the selected models (e.g., $7Q_2$, $7Q_{20}$, for LOF: Graphical Index Method), which will be displayed in the 'View Results' menu.

Results for the Selected Flow Prediction Models

The 'View Results' menu is divided into five available categories for viewing. Clicking on any of the active buttons will display the results for that category (not shown). The 'View All' button will display the results for all the selected models in the same window.


View Results
Flow Prediction Models
Low Flow Prediction Models (LOF)
Flood Prediction Models (HIF)
Mean Annual Flow Prediction Models (MAF)
Minimum Instream Flow Requirement Models (IFR)
Bankfull Discharge Prediction Models (BFQ)
Waterpower Potential Estimation Models (WPP)
View All Results
Export All Results
Close
View Warnings
NOTE:

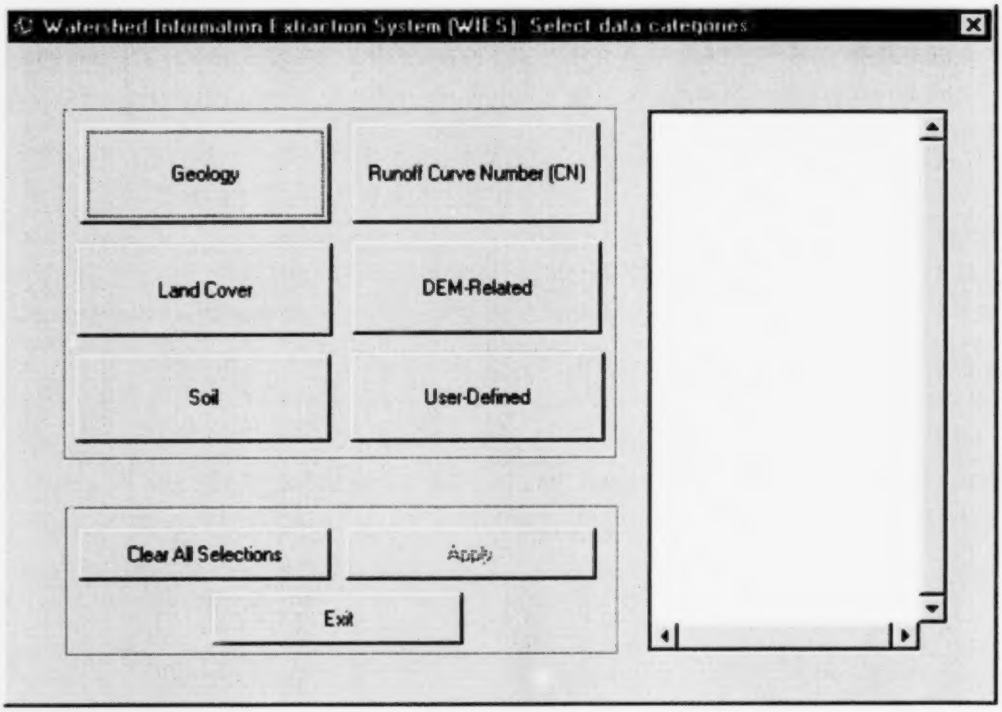
Each model in OFAT has its own limitations. Please refer to the original model document, or if necessary a water professional, before using generated flow values for any decision making purpose.

✎ ***Note**: When a button is not active, no models in that category were selected to run.*

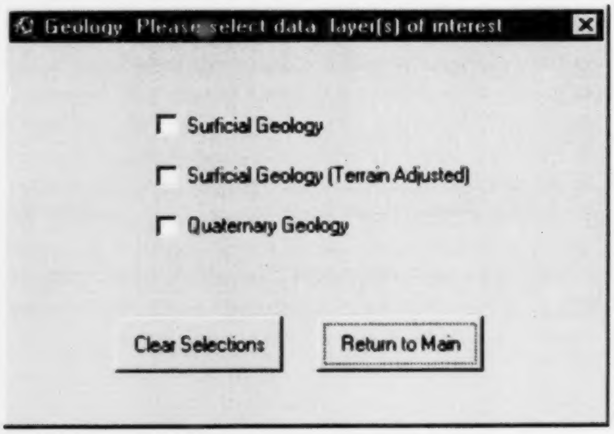
When modelling results need to be saved, 'Export All Results' on the 'View Results' menu can be used. This process prompts for a file name and file type, then exports all of the results to the user-specified file.

Watershed Information Extraction System (WIES)

This module can be accessed after a watershed is imported or at any time after a watershed is delineated. To open WIES, click on the button and the following WIES main menu will be displayed:

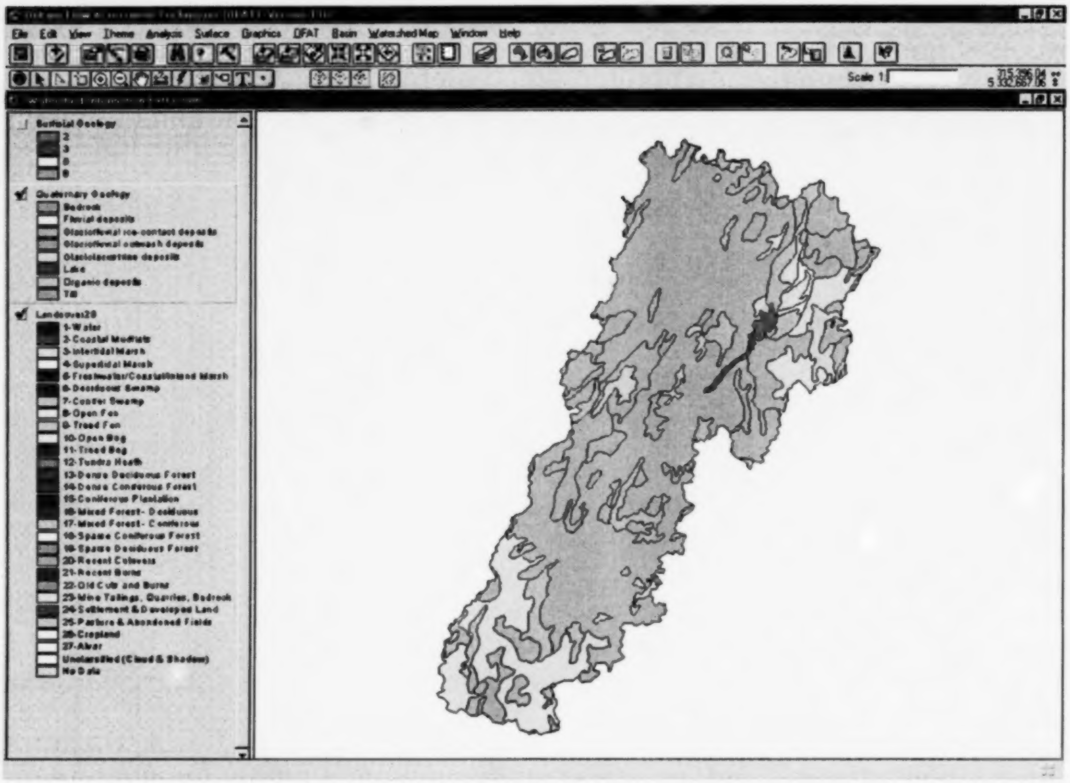

Watershed Information Extraction System (WIES): Select data categories
Geology
Runoff Curve Number (CN)
Land Cover
DEM-Related
Soil
User-Defined
Clear All Selections
Apply
Exit

The WIES main menu allows the selection of data layers to be clipped to the current delineated watershed. Six data categories are available for selection, each represented by a button on the menu. A layer selection dialog box will appear after a category (e.g., Geology) has been chosen.

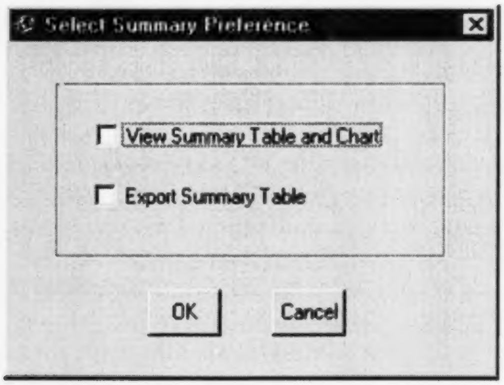

Geology: Please select data layer(s) of interest
☐ Surficial Geology
☐ Surficial Geology (Terrain Adjusted)
☐ Quaternary Geology
Clear Selections
Return to Main

To select a data layer, check the boxes on the dialog box. Once all selections have been made for the category, click the 'Return to Main' button to return to the WIES main menu. The selected data layers will be displayed in the list on the WIES main menu. Data layers can be selected from as many categories as needed, returning to the WIES main menu after each selection. Once all the needed data layers have been selected, click the 'Apply' button.

WIES will then extract the selected layers to the watershed and display them in a map called 'Watershed Information Extraction'.

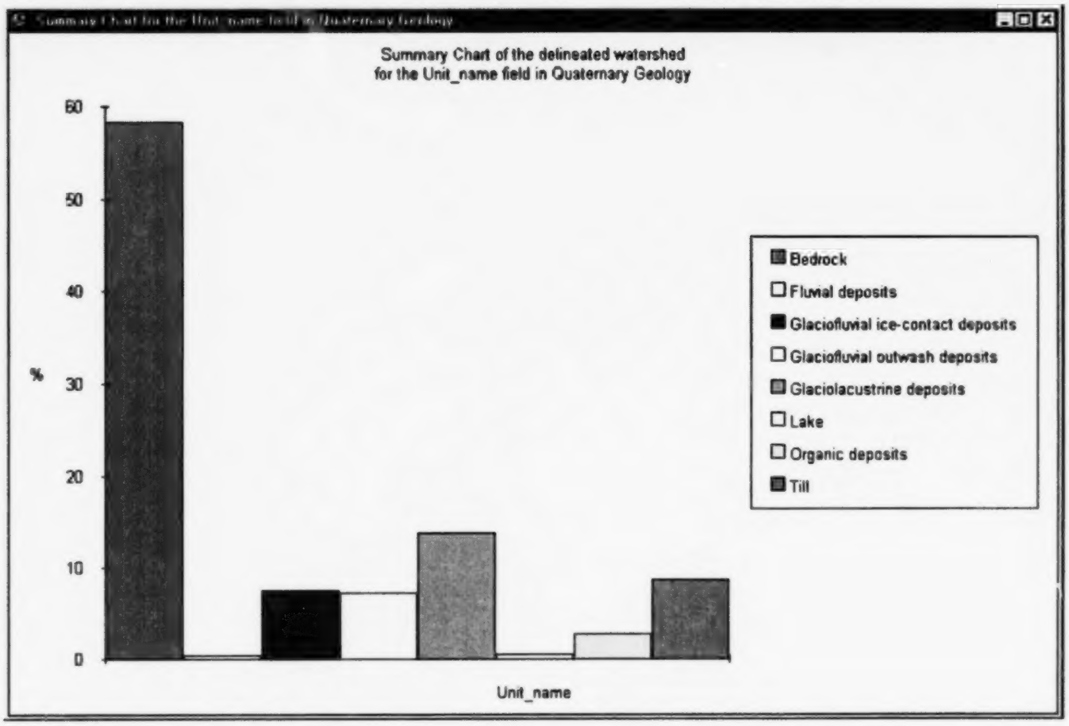

File Edit View Theme Analysis Surface Graphics OFAT Basin WatershedMap Window Help
Scale 1:
Surficial Geology
2
3
8
9
Quaternary Geology
Bedrock
Fluvial deposits
Glaciofluvial ice-contact deposits
Glaciofluvial outwash deposits
Glaciolacustrine deposits
Lake
Organic deposits
Till
Landcover28
1-Water
2-Coastal Mudflats
3-Intertidal Marsh
4-Supratidal Marsh
5-Freshwater/Coastal/Inland Marsh
6-Deciduous Swamp
7-Conifer Swamp
8-Open Fen
9-Treed Fen
10-Open Bog
11-Treed Bog
12-Tundra Heath
13-Dense Deciduous Forest
14-Dense Coniferous Forest
15-Coniferous Plantation
16-Mixed Forest- Deciduous
17-Mixed Forest- Coniferous
18-Sparse Coniferous Forest
19-Sparse Deciduous Forest
20-Recent Cutovers
21-Recent Burns
22-Old Cuts and Burns
23-Mine Tailings, Quarries, Bedrock
24-Settlement & Developed Land
25-Pasture & Abandoned Fields
26-Cropland
27-Alvar
Unclassified (Cloud & Shadow)
No Data

The 'WIES Summary Statistics' button on the toolbar will now become active. This function summarizes the active data layers found in the 'Watershed Information Extraction' map. Once the button is clicked, the 'Select Summary Preference' dialog box is displayed. Select one or both of the checkboxes and press 'OK'.


Select Summary Preference
☐ View Summary Table and Chart
☐ Export Summary Table
OK
Cancel

Viewing Summary Table and Chart

When the 'View Summary Table and Chart' option is selected, the user is prompted to select a field of an active data layer to summarize. A summary table (not shown) and chart (below) are then produced for each of the active data layers.

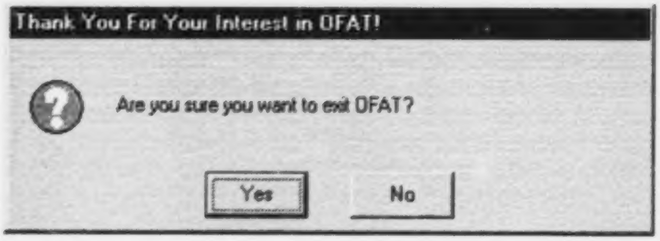

Summary Chart for the Unit_name field in Quaternary Geology
Summary Chart of the delineated watershed
for the Unit_name field in Quaternary Geology
60
50
40
%
30
20
10
0
Unit_name
▨ Bedrock
☐ Fluvial deposits
■ Glaciofluvial ice-contact deposits
☐ Glaciofluvial outwash deposits
▨ Glaciolacustrine deposits
☐ Lake
☐ Organic deposits
▨ Till

Exporting the Summary Table

When the 'Export Summary Table' option is selected, the user is prompted to select a field of an active data layer to summarize. The user is also prompted to select the type of export file. Once an export format is chosen, a menu appears prompting for the name and the path of the exported file.

Exiting OFAT

At any time during the OFAT session you may exit the program by clicking on the ☒ in the upper right corner of the ArcView window or the upper right corner of the Project window. You may also exit OFAT through the 'Exit' item in the 'File' pull down menu. A dialog box will appear verifying if you want to exit the program.



Thank You For Your Interest in OFAT!

Are you sure you want to exit OFAT?

Watershed Delineation

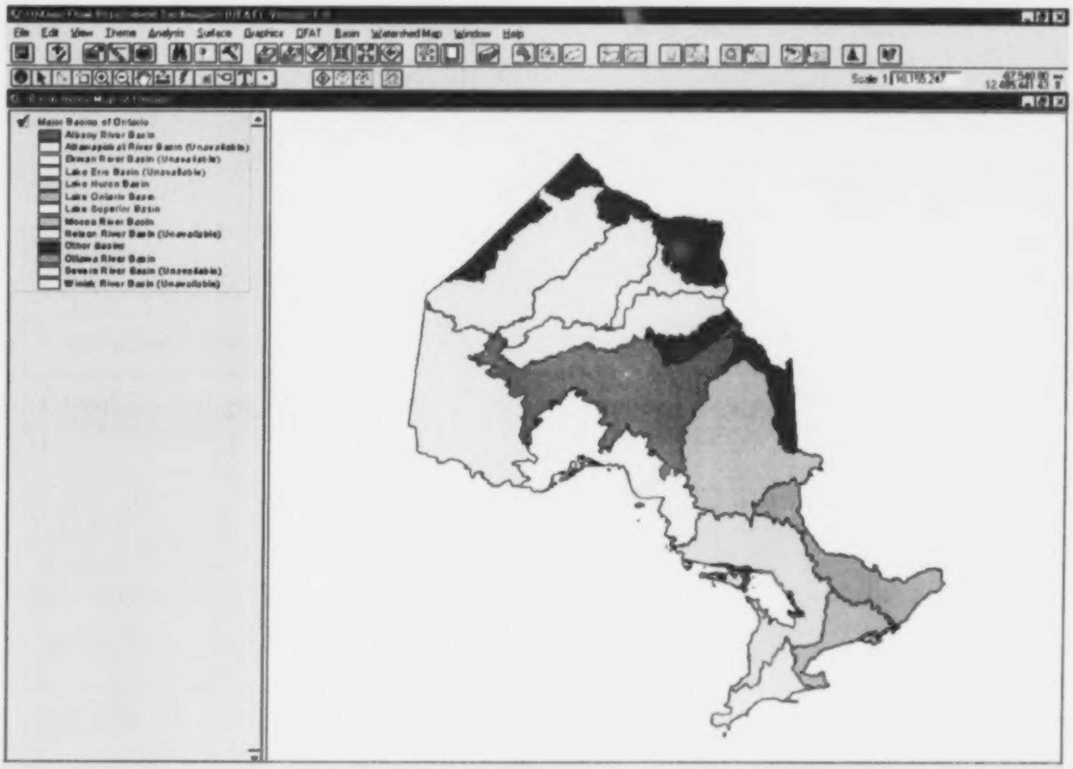
Four major steps are involved in delineating a watershed.

1. Selecting a major basin
2. Selecting a tertiary watershed
3. Selecting a DEM
4. Specifying a watershed outlet

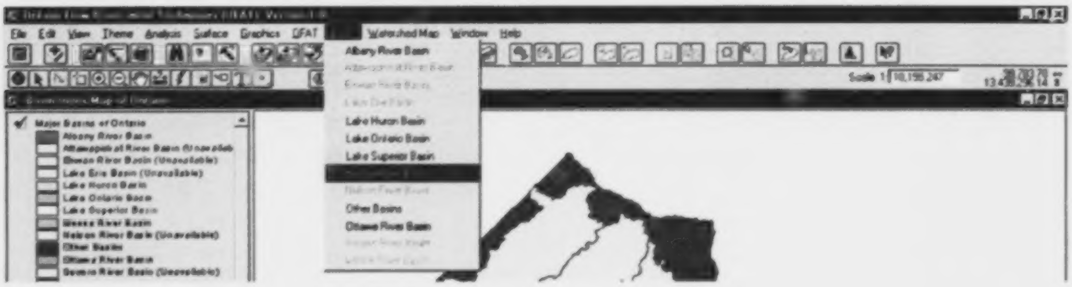
Step one and two are used to narrow down the geographical location within Ontario to an area of the user's interest. The fourth step involves selecting the location of the watershed outlet using the mouse or by entering the UTM co-ordinates using the keyboard.

Selecting a Major Basin

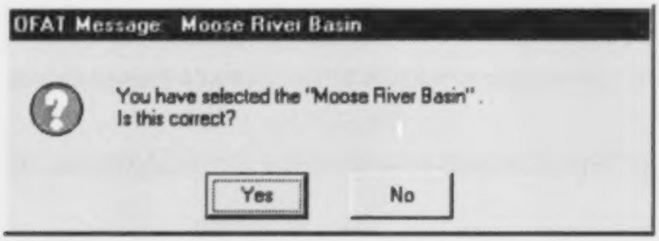
The first map in OFAT is the 'Basin Index Map of Ontario' showing the 13 major basins. Basins available for selection are colour coded and named within the table of contents. If the database associated with a basin is not currently installed, the basin will be coloured grey and will not be available for selection.


File Edit View Theme Analysis Surface Graphics OFAT Basin WatershedMap Window Help
Major Basins of Ontario
Albany River Basin
Attawapiskat River Basin (Unavailable)
Ekwan River Basin (Unavailable)
Lake Erie Basin (Unavailable)
Lake Huron Basin
Lake Ontario Basin
Lake Superior Basin
Moose River Basin
Nelson River Basin (Unavailable)
Other Basins
Ottawa River Basin
Severn River Basin (Unavailable)
Winisk River Basin (Unavailable)

You can select a major basin by using the tool on the toolbar. This tool is active when the 'Basin Index Map of Ontario' is displayed. Place the cursor over the desired basin and click. Another selection method is available through the 'Basin' pull down menu, which displays the basin names available. Find the desired basin and select it.


File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Watershed Map
Window
Help
Albany River Basin
Lake Huron Basin
Lake Ontario Basin
Lake Superior Basin
Other Basins
Ottawa River Basin
Major Basins of Ontario
Albany River Basin
Attawapiskat River Basin (Unavailable)
Ekwan River Basin (Unavailable)
Lake Erie Basin (Unavailable)
Lake Huron Basin
Lake Ontario Basin
Lake Superior Basin
Moose River Basin
Nelson River Basin (Unavailable)
Other Basins
Ottawa River Basin
Severn River Basin (Unavailable)
Scale 1: 10,199,247

If a major basin is selected by using the tool, the following message will appear, asking the user to verify their selection.

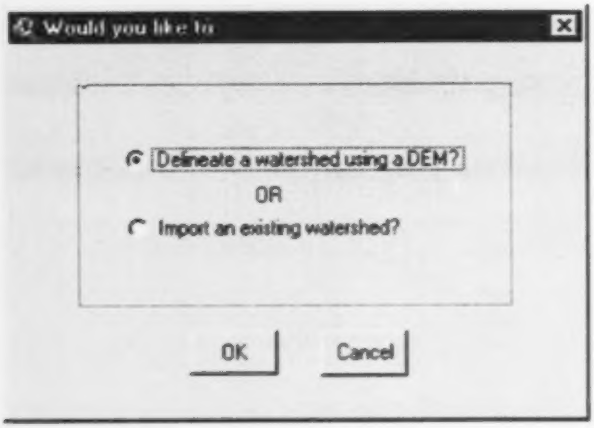

OFAT Message: Moose River Basin

You have selected the "Moose River Basin". Is this correct?

Clicking 'No' will reopen the 'Basin Index Map of Ontario' and allow another selection to be made.

✎ **Note:** *At any time during an OFAT session if a different major basin is required, click the button or choose the 'Basin Index Map of Ontario' item in the 'Watershed Map' pull down menu. This will open the 'Basin Index Map of Ontario' map.*

Click 'Yes' to proceed. The tertiary watershed index map appears with the name of the selected major basin. When this map is first displayed, the following menu will appear asking if a watershed is to be delineated or imported.



Would you like to

● Delineate a watershed using a DEM?

OR

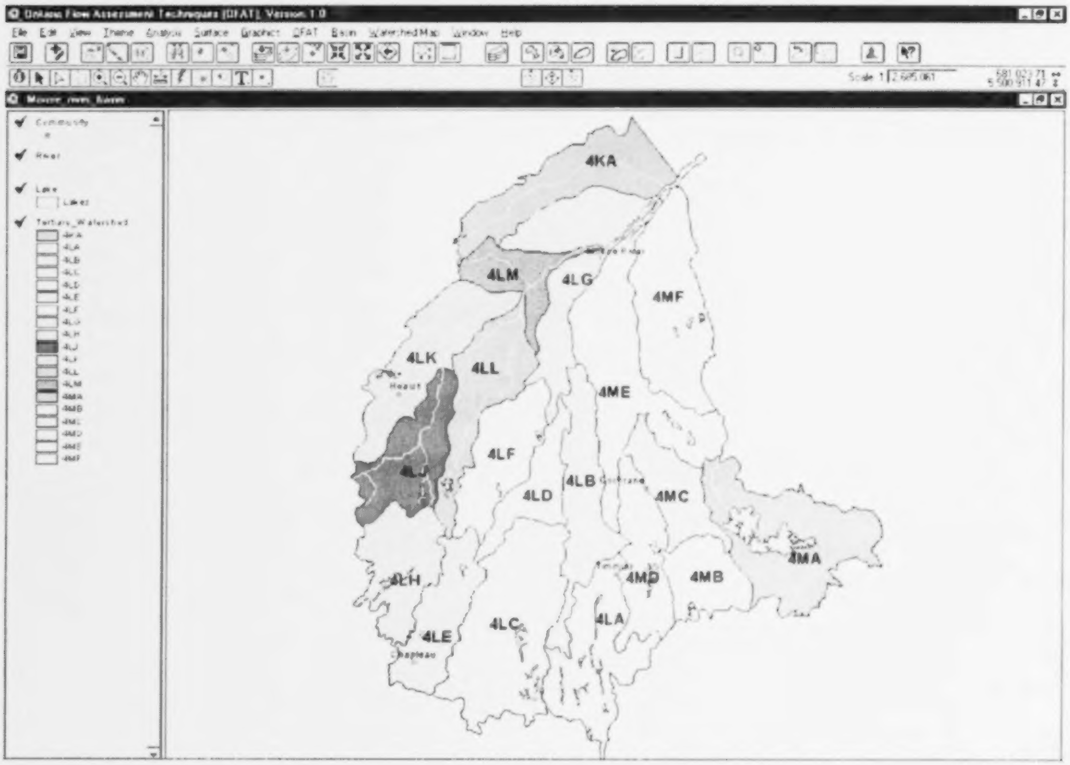
○ Import an existing watershed?

When the 'Delineate a watershed using a DEM?' option is selected, the tertiary watershed index map will become active.

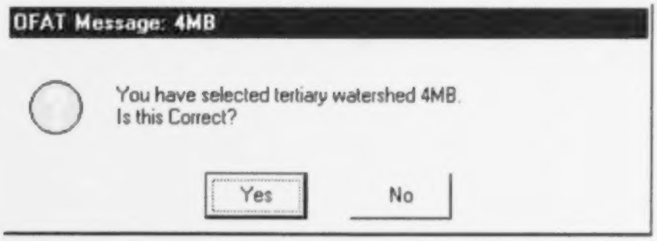
When the 'Import an existing watershed?' option is selected, please refer to the 'Importing a Watershed' section of this chapter.

Selecting a Tertiary Watershed

The tertiary watershed index map shows the selected major basin divided into tertiary watersheds. Selected communities, rivers and lakes are visible on this map to help identify the desired tertiary watershed, which contains the watershed outlet of interest.


Ontario Flow Assessment Techniques (OFAT), Version 1.0
File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Community
River
Lake
Lakes
Tertiary_Watershed
4KA
4LM
4LG
4MF
4LK
4LL
4ME
4LF
4LD
4LB
4MC
4MA
4LH
4MD
4MB
4LE
4LC
4LA
Hearst
Cochrane
Chapleau

At this point, the ⊕ tool will become active on the toolbar. This tool is necessary to select the tertiary watershed that contains the watershed outlet of interest. Once a tertiary watershed is selected, a message will appear asking the user to verify their selection.

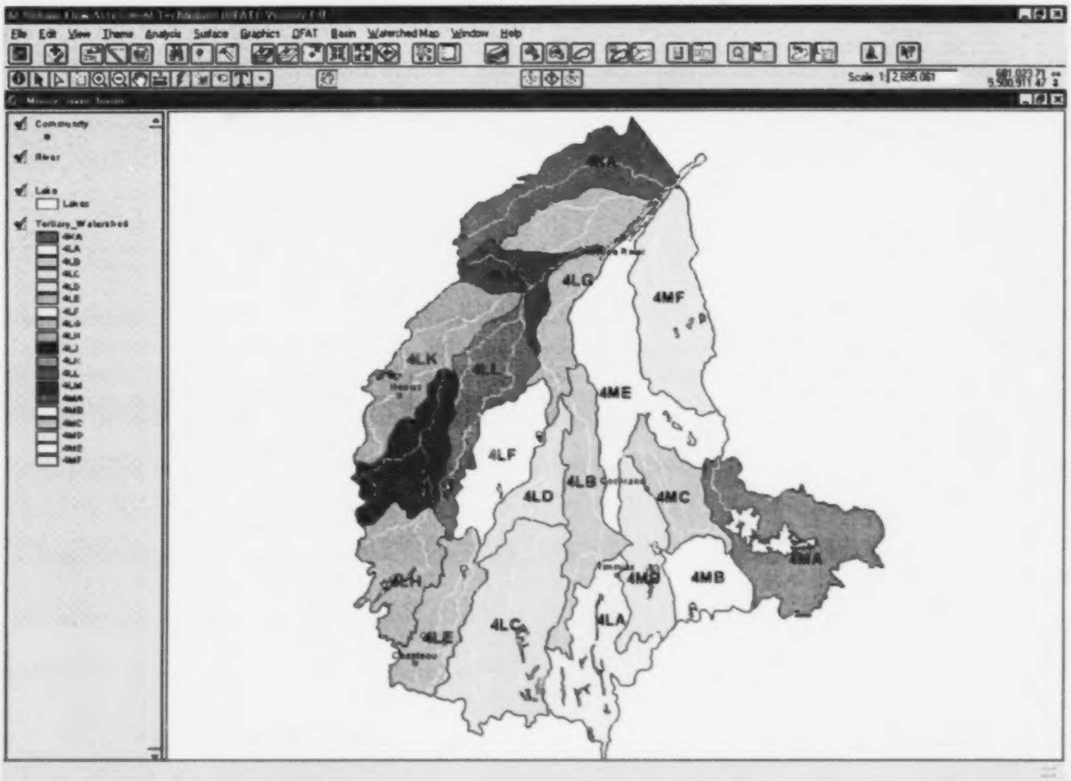


OFAT Message: 4MB

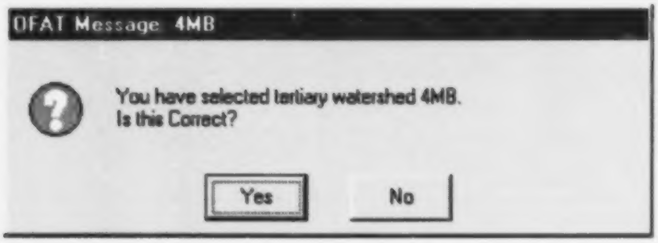
You have selected tertiary watershed 4MB.
Is this Correct?

Selecting a Tertiary Watershed

The tertiary watershed index map shows the selected major basin divided into tertiary watersheds. Selected communities, rivers and lakes are visible on this map to help identify the desired tertiary watershed, which contains the watershed outlet of interest.


File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Community
River
Lake
Lakes
Tertiary_Watershed
4KA
4LA
4LB
4LC
4LD
4LE
4LF
4LG
4LH
4LJ
4LK
4LL
4LM
4MA
4MB
4MC
4MD
4ME
4MF
4LG
4MF
4LK
4LL
4ME
4LF
4LD
4LB
4MC
4MA
4MB
4MD
4LH
4LC
4LA
4LE

At this point, the ⊕ tool will become active on the toolbar. This tool is necessary to select the tertiary watershed that contains the watershed outlet of interest. Once a tertiary watershed is selected, a message will appear asking the user to verify their selection.


OFAT Message 4MB

You have selected tertiary watershed 4MB.
Is this Correct?

If 'No' is selected, the tertiary watershed index map will become active again and another tertiary watershed can be selected.

✎ ***Note:*** *At any time during the OFAT session if a different tertiary watershed is required, click the button or choose the 'Tertiary Watershed Index Map' item in the 'Watershed Map' pull down menu. This will open the tertiary watershed index map of the currently selected major basin.*

If 'Yes' is selected, the next step is to choose a DEM.

Selecting a DEM

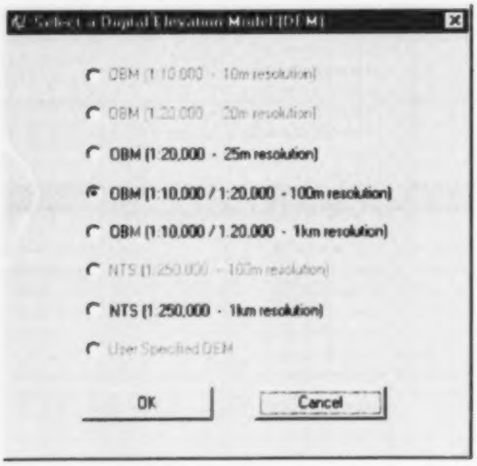
DEM selection is a very important step in OFAT. The processing time and accuracy for watershed delineation is dependent on the selected DEM so the user should choose wisely. For example, it would not be wise to select a 1km resolution DEM to delineate a watershed with a drainage area of only 2.0 km^2.

! ***Warning****: Please keep in mind that generally speaking, the finer the resolution of DEM, the longer the processing time. However, finer resolutions are recommended for delineating smaller watersheds due to higher accuracy.*

OFAT gives the choice of DEMs at seven different resolutions as illustrated in the menu below. However, some options may be dimmed out because DEM data for that option is unavailable or not installed.

Select the desired DEM and click 'OK' to continue. The 'Cancel' button will return the user to the tertiary watershed index map from which a different tertiary watershed can be selected.

✎ ***Note****: Currently the 'User Specified DEM' option is not available.*

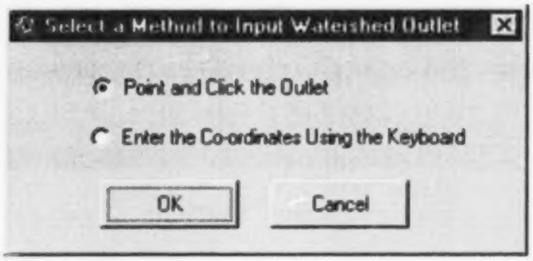


Select a Digital Elevation Model (DEM)

○ OBM (1:10,000 - 10m resolution)
○ OBM (1:20,000 - 20m resolution)
○ OBM (1:20,000 - 25m resolution)
● OBM (1:10,000 / 1:20,000 - 100m resolution)
○ OBM (1:10,000 / 1:20,000 - 1km resolution)
○ NTS (1:250,000 - 100m resolution)
○ NTS (1:250,000 - 1km resolution)
○ User Specified DEM

Specifying a Watershed Outlet

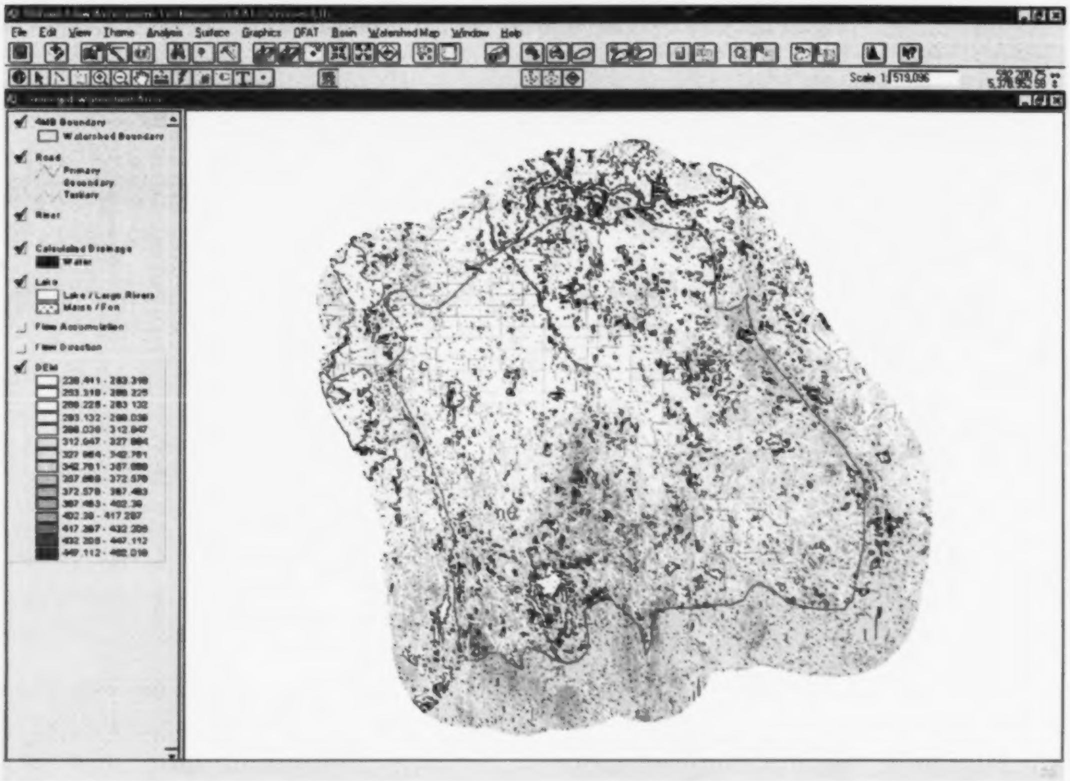
After the DEM is selected, the 'Select a Method to Input Watershed Outlet' menu appears. This allows the user to choose the method for inputting the watershed outlet.


Select a Method to Input Watershed Outlet
● Point and Click the Outlet
○ Enter the Co-ordinates Using the Keyboard
OK
Cancel

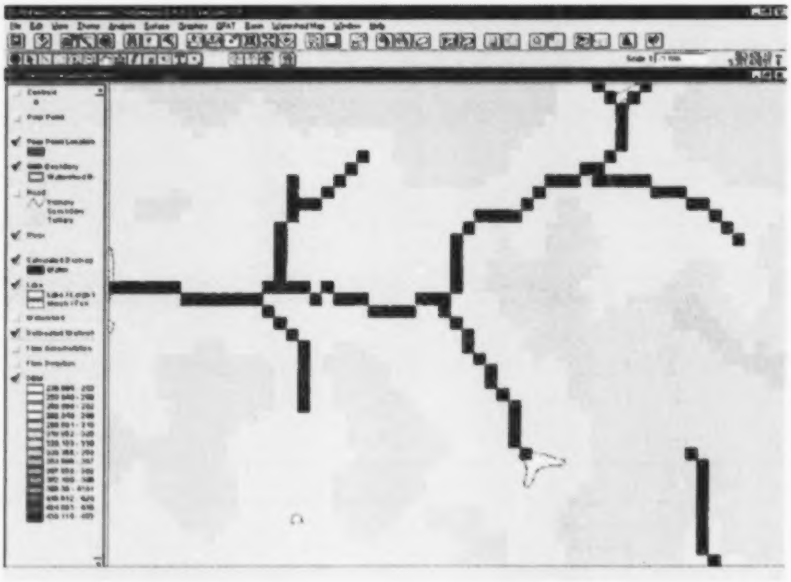
Point and Click the Outlet

When the 'Point and Click the Outlet' option is selected, the 'Selected Watershed Area' map will be displayed. This map contains detailed layers of rivers, roads, lakes and wetlands, etc. The general outline of the selected tertiary watershed is coloured in purple with DEM-related grids extending ten kilometres beyond the outline.

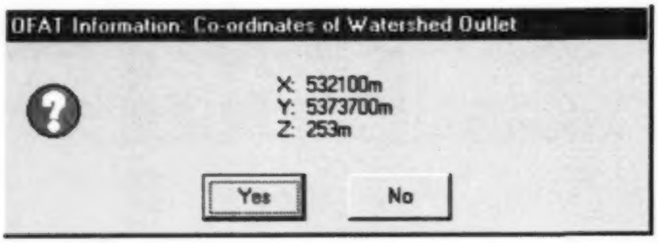
✎ ***Note***: *If you wish to add your own data to this map to help facilitate finding the location of the watershed outlet, please refer to Appendix A for projection information of each major basin.*


File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Scale 1:
4MB Boundary
Watershed Boundary
Road
Primary
Secondary
Tertiary
River
Calculated Drainage
Water
Lake
Lake / Large Rivers
Marsh / Fen
Flow Accumulation
Flow Direction
DEM

At this point, it is recommended that the map be zoomed in to the area of interest. This will ensure that the cursor is clicked over the exact location of the watershed outlet.


Pour Point
4MB Boundary
Road
River
Calculated Drainage
Lake
DEM

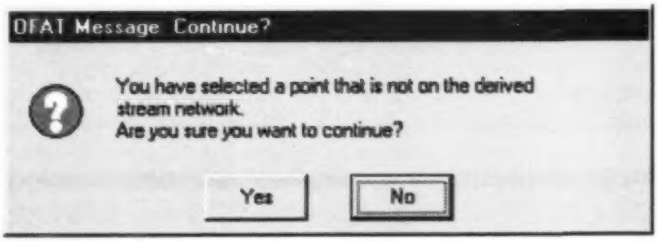
The 'Calculated Drainage' (the blue raster layer) has been derived using the chosen DEM. Click on this raster-based drainage network to select a watershed outlet. When the watershed outlet is selected, a message will appear showing the UTM co-ordinates and the elevation of the outlet point.


OFAT Information: Co-ordinates of Watershed Outlet

X: 532100m
Y: 5373700m
Z: 253m

To proceed with watershed delineation for the outlet point, click 'Yes'. To return to the 'Selected Watershed Area' map and select a different outlet point, click 'No'.

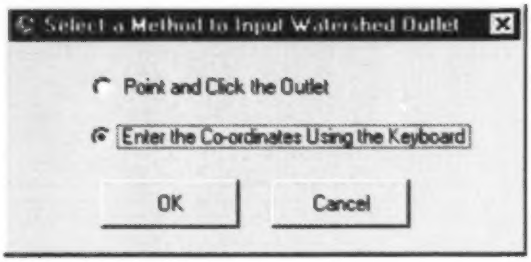
If the outlet location you have selected is not located on the blue raster-based drainage network, the following message will appear. To reselect an outlet point, click 'No'. To continue with watershed delineation using the current selected point, click 'Yes'. Please be advised that if you continue at this point, most likely the delineated watershed will not correspond with the desired area of your interest.


OFAT Message: Continue?

You have selected a point that is not on the derived stream network.
Are you sure you want to continue?

Enter the Watershed Outlet Co-ordinates Using Keyboard

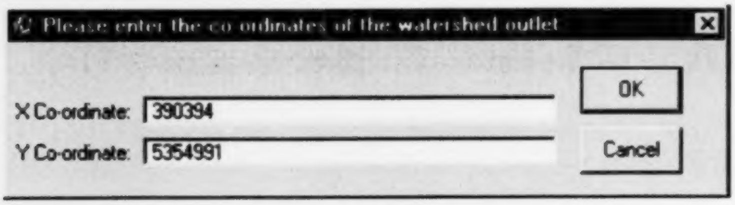
The other method to input the watershed outlet for watershed delineation is by selecting the 'Enter the Co-ordinates Using the Keyboard' option.


Select a Method to Input Watershed Outlet

○ Point and Click the Outlet
● Enter the Co-ordinates Using the Keyboard

If this option is selected, a menu appears prompting the user to enter the UTM X (easting) and Y (northing) co-ordinates for the outlet point.

✎ ***Note**: Please refer to Appendix A for projection information of each major basin.*

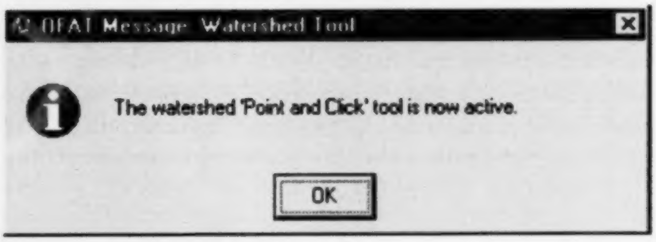


Please enter the co-ordinates of the watershed outlet

X Co-ordinate: 390394

Y Co-ordinate: 5354991

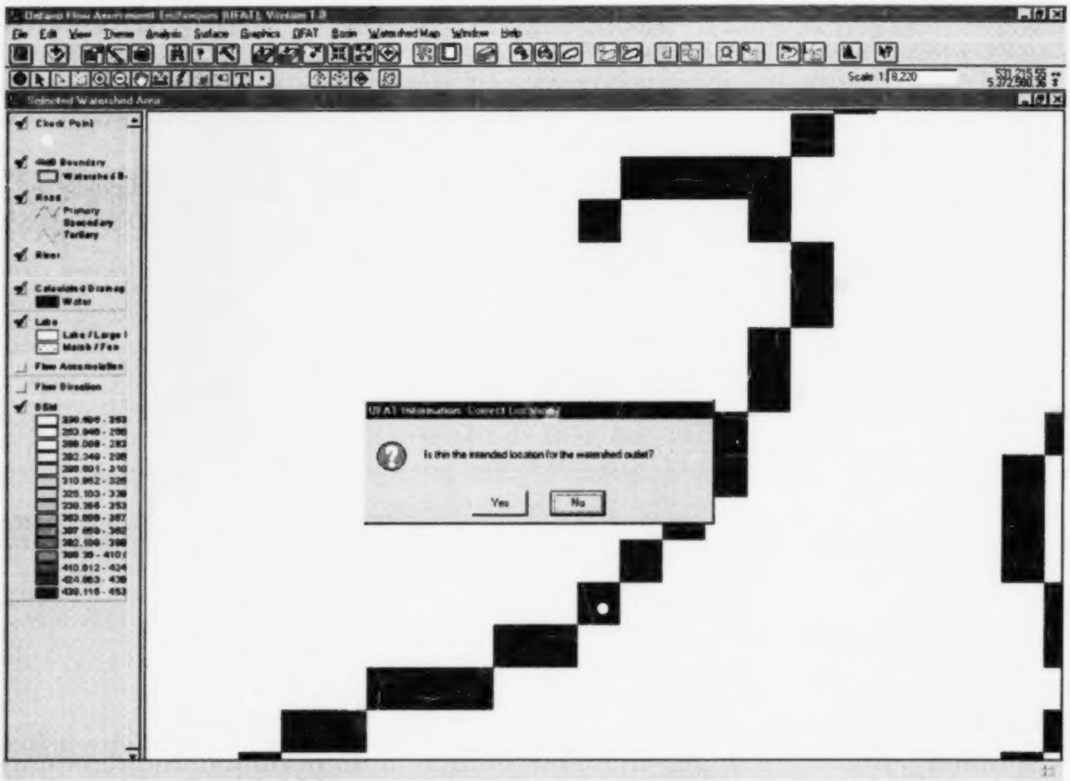
If the process is cancelled by clicking on 'Cancel' button, the 'Selected Watershed Area' map will become active with the 'Point and Click' tool activated.



OFAT Message: Watershed Tool

The watershed 'Point and Click' tool is now active.

Once the co-ordinates are entered, click 'OK'. The 'Selected Watershed Area' map becomes visible with a yellow dot showing the location of the entered co-ordinates. A message appears asking if the location of the dot was the one intended.


Ontario Flow Assessment Techniques (OFAT), Version 1.0
File Edit View Theme Analysis Surface Graphics OFAT Basin WatershedMap Window Help
Scale 1:8,220
Selected Watershed Area
Check Point
Boundary
Watershed B.
Roads
Primary
Secondary
Tertiary
Rivers
Calculated Drainage
Water
Lake
Lake / Large
Marsh / Fen
Flow Accumulation
Flow Direction
DEM
OFAT Information: Correct Location?
Yes
No

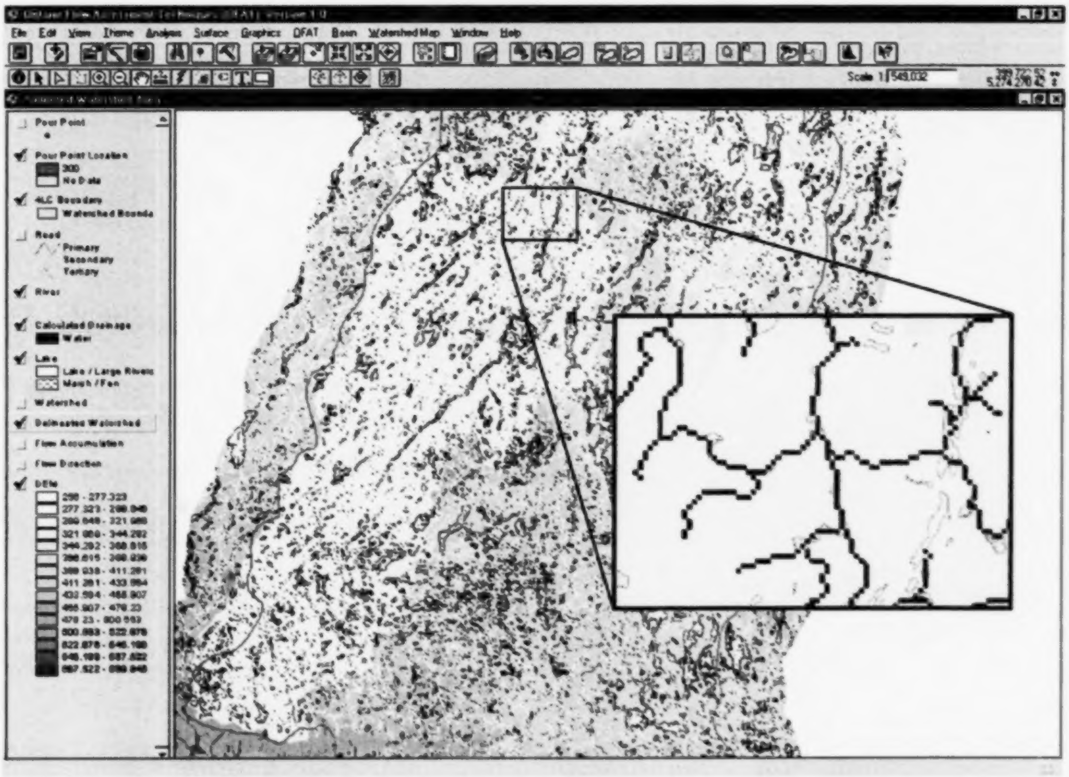
Is this the intended location for the watershed outlet?

Clicking 'Yes' will allow the process to continue and the watershed will be delineated with the entered outlet point. Clicking 'No' will return to the co-ordinate input menu where the co-ordinates can be re-entered.

The Delineated Watershed

After the watershed has been delineated, the 'Selected Watershed Area' map will zoom into the spatial extent of the delineated watershed, which appears in green with a red square. The red square represents the watershed outlet.

- ✎ ***Note:*** *The original tertiary watershed boundaries were manually traced and digitized based on 1:600,000 provincial paper maps, producing general boundary outlines (coloured in purple). The boundaries delineated in OFAT are much more accurate since the DEMs were generated based on elevation data of a larger scale (i.e., 1:10,000 for southern and 1:20,000 for northern Ontario). In the future, new tertiary watershed boundaries will be generated using the most up-to-date DEMs so they will match the watershed boundaries delineated by OFAT.*


File
Edit
View
Theme
Analysis
Surface
Graphics
OFAT
Basin
WatershedMap
Window
Help
Scale 1:549,032
Pour Point
Pour Point Location
300
No Data
4LC Boundary
Watershed Bounda
Road
Primary
Secondary
Tertiary
River
Calculated Drainage
Water
Lake
Lake / Large Rivers
Marsh / Fen
Watershed
Delineated Watershed
Flow Accumulation
Flow Direction
DEMs

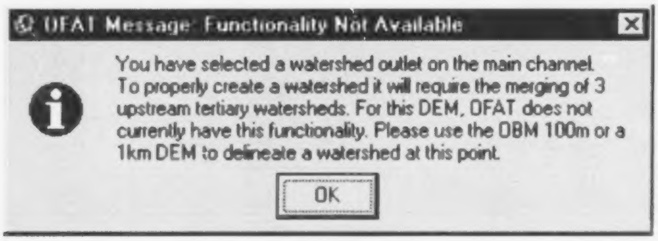
At this stage, the 'Watershed Calculator' and/or the 'Watershed Information Extraction System (WIES)' can be accessed. Both of these components are explained in detail later in this manual.

Delineating Watersheds Spanning Multiple Tertiary Watersheds

If the outlet point of interest falls on the main channel of a downstream tertiary watershed, the watershed to be delineated will span multiple tertiary watersheds. It includes the tertiary watershed where the outlet is located and the related upstream tertiary watersheds in the current major basin. If this occurs, the DEM-related data will have to be merged in order to delineate the entire watershed. Currently, the merging function can only be applied to the DEMs with 100m resolution.

The 1km resolution DEM is another option to delineate a watershed spanning multiple tertiary watersheds. Since the 1km resolution DEM covers the extent of the entire major basin, the merging function is not required and processing time is substantially reduced.

If the resolution of the selected DEM is 10m or 20m, a message box similar to the one shown below will appear. Click 'OK' and the 'Selected Watershed Area' map will become active for another point selection.

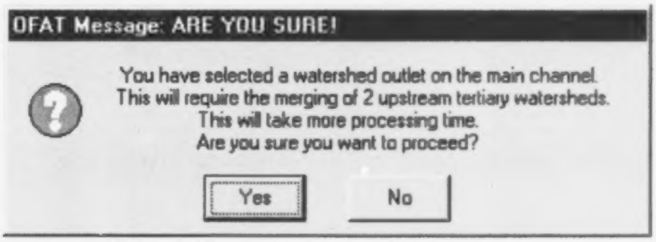


OFAT Message: Functionality Not Available

You have selected a watershed outlet on the main channel.
To properly create a watershed it will require the merging of 3 upstream tertiary watersheds. For this DEM, OFAT does not currently have this functionality. Please use the OBM 100m or a 1km DEM to delineate a watershed at this point.

✎ ***Note**: In order to select another resolution of DEM, the user must return to the tertiary watershed index map using the ⊕ tool and reselect the tertiary watershed.*

When using the merging function with the 100m resolution DEMs, a message box similar to the one below will appear. This message box shows the number of upstream tertiary watersheds that need to be merged.

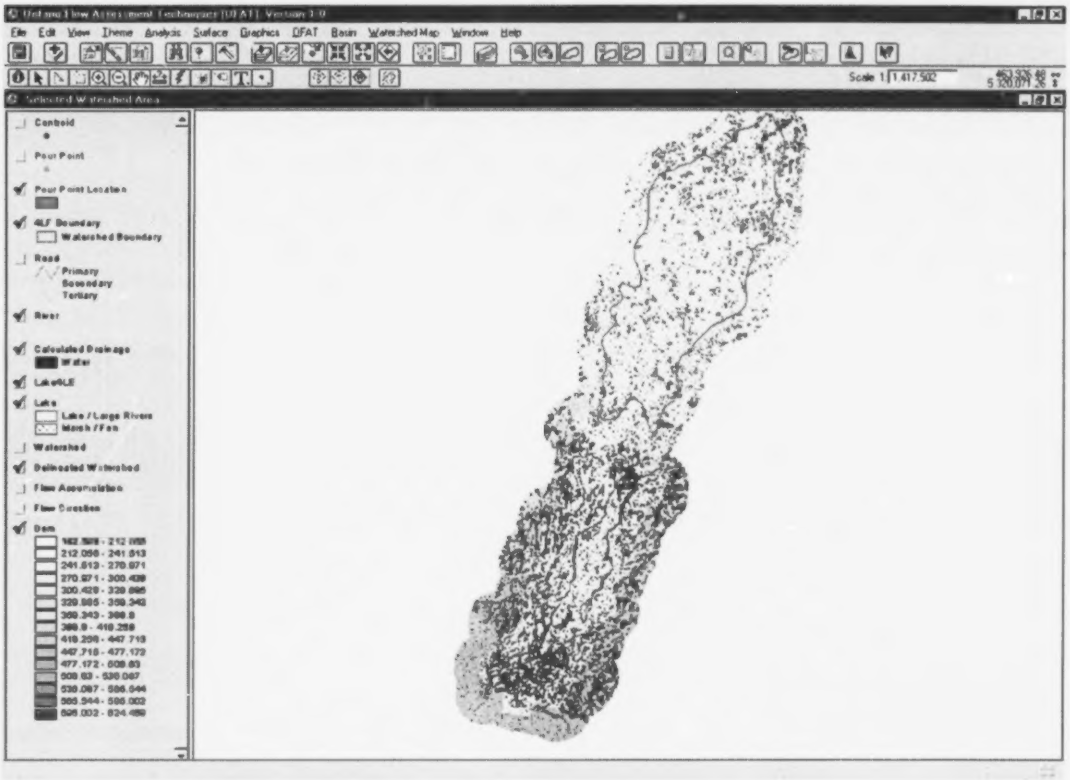


OFAT Message: ARE YOU SURE!

You have selected a watershed outlet on the main channel.
This will require the merging of 2 upstream tertiary watersheds.
This will take more processing time.
Are you sure you want to proceed?

! ***Warning**: Merging tertiary watersheds will take time! If it is known that the watershed of interest will be large, the user may consider using a 1km resolution DEM.*

Clicking 'No' allows the user to select another outlet. If 'Yes' is chosen, the DEM-related data of all involved tertiary watersheds is merged and a watershed is delineated for the specified watershed outlet. The resulting delineated watershed will be shown in the 'Selected Watershed Area' map in green.

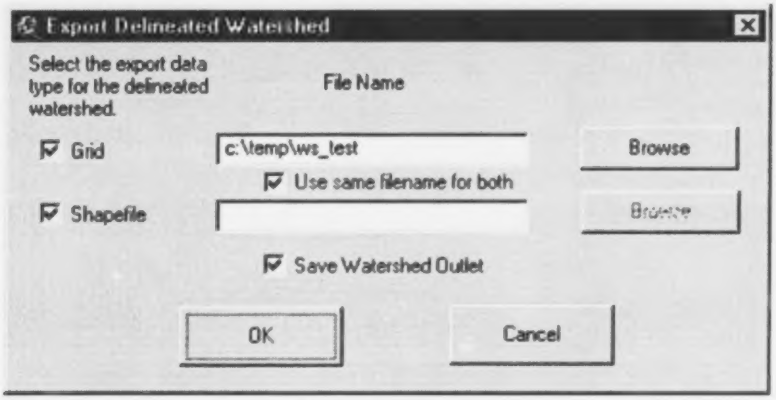

Ontario Flow Assessment Techniques (OFAT), Version 1.0
File Edit View Theme Analysis Surface Graphics OFAT Basin WatershedMap Window Help
Scale 1: 1,417,502
Selected Watershed Area
Centroid
Pour Point
Pour Point Location
4LF Boundary
Watershed Boundary
Road
Primary
Secondary
Tertiary
River
Calculated Drainage
Water
Lake4LE
Lake
Lake / Large Rivers
Marsh / Fen
Watershed
Delineated Watershed
Flow Accumulation
Flow Direction
Dem
212.058 - 241.513
241.513 - 270.971
270.971 - 300.428
300.428 - 329.885
329.885 - 359.343
359.343 - 388.8
388.8 - 418.258
418.258 - 447.715
447.715 - 477.172
477.172 - 506.63
506.63 - 536.087
536.087 - 565.544
565.544 - 595.002
595.002 - 624.459

Note: Not all of the data layers available in the original map are added for the upstream tertiary watersheds when merging DEM-related data. Only the layers needed for delineation and/or for other OFAT components will be added to the map.

Once the DEM-related data have been merged, new watersheds delineated within the same tertiary watershed will use the merged data without a prompt regarding merging.

Saving the Watershed Boundary

After a watershed has been delineated, the 'Save Watershed' button becomes available. This function allows the user to save the delineated watershed and/or watershed outlet to an ArcInfo grid and/or shapefile data set.



Export Delineated Watershed

Select the export data type for the delineated watershed.

File Name

☑ Grid: c:\temp\ws_test

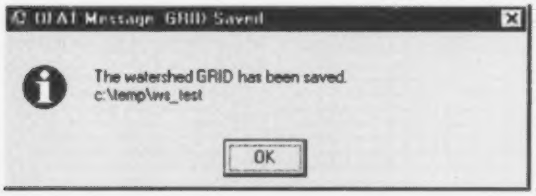
☑ Use same filename for both

☑ Shapefile:

☑ Save Watershed Outlet

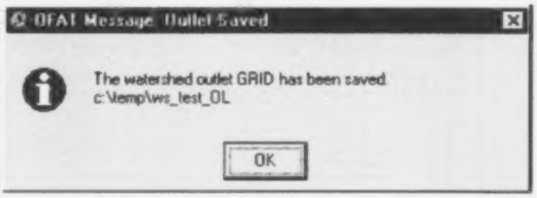
The export menu uses the check boxes on the left to select which data type to save the delineated watershed in. The filename of each watershed data type can be specified in the corresponding text boxes. If the path to the file is not known, the 'Browse' button will open up the file dialog, and the file path can be browsed to and the file name specified. The 'Use same filename for both' checkbox allows one filename to be entered for both data types. When this is checked only the top text input line will allow a filename to be entered.

Checking the 'Save Watershed Outlet' check box will save the outlet in the selected data types. The outlet file will be saved with the same name as the watershed file, but with an "_OL" added (see example below). Click 'OK' to start saving. A message box will display the success of each save process.



OFAT Message GRID Saved

The watershed GRID has been saved.
c:\temp\ws_test



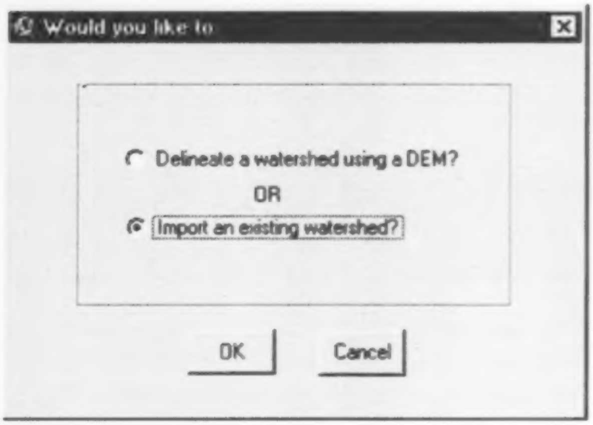
OFAT Message Outlet Saved

The watershed outlet GRID has been saved.
c:\temp\ws_test_OL

Importing a Watershed

The 'Import an existing watershed?' option from the menu below allows the user to import an ArcInfo grid or polygon shapefile. Currently imported watersheds can be used for analysis within the 'Watershed Information Extraction System (WIES)' component only.

✎ ***Note****: Imported watersheds must be in the same projection as the existing OFAT data. Please refer to Appendix A for projection information for each major basin.*

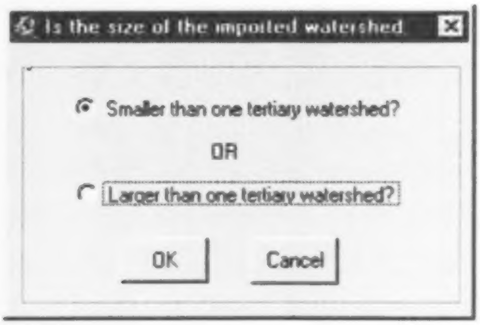

Would you like to

○ Delineate a watershed using a DEM?

OR

● Import an existing watershed?

When importing a watershed, a menu will appear asking if the size of the watershed is smaller or larger than one tertiary watershed. If the imported watershed is larger than one tertiary watershed only the 1km or 100m resolution DEMs are available for selection. When using the import option, the DEM will not be used for watershed delineation but it is still needed for some WIES functions.


Is the size of the imported watershed

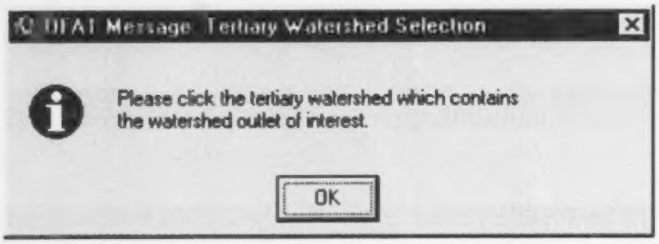
● Smaller than one tertiary watershed?

OR

○ Larger than one tertiary watershed?

Importing Watersheds Smaller Than One Tertiary Watershed

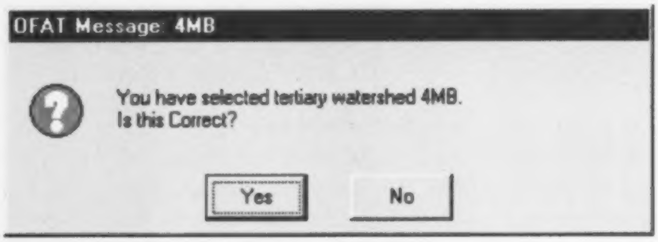
When the 'Smaller than one tertiary watershed?' option is selected, the program will prompt you to select the tertiary watershed in which the imported watershed falls within.



OFAT Message: Tertiary Watershed Selection

Please click the tertiary watershed which contains the watershed outlet of interest.

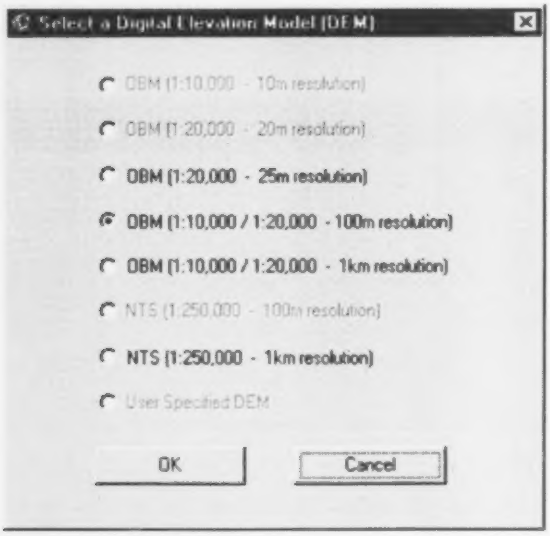
As with the 'Delineate a watershed using a DEM?' option, described previously, the tertiary watershed is selected with the cursor using the tool. After selecting a tertiary watershed, a message box appears asking if the tertiary watershed selection is correct.



OFAT Message: 4MB

You have selected tertiary watershed 4MB.
Is this Correct?

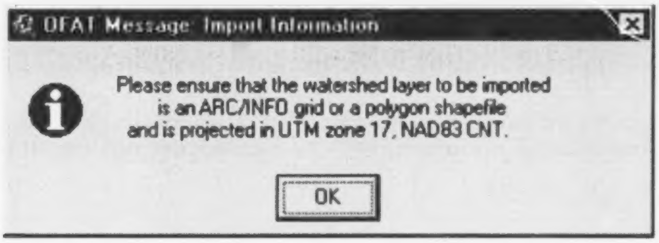
If the tertiary watershed selected is not the one of interest, clicking 'No' will allow another tertiary watershed to be selected. Clicking 'Yes' will continue the process and opens the following menu allowing a DEM to be selected.



Select a Digital Elevation Model (DEM)

○ OBM (1:10,000 - 10m resolution)
○ OBM (1:20,000 - 20m resolution)
○ OBM (1:20,000 - 25m resolution)
● OBM (1:10,000 / 1:20,000 - 100m resolution)
○ OBM (1:10,000 / 1:20,000 - 1km resolution)
○ NTS (1:250,000 - 100m resolution)
○ NTS (1:250,000 - 1km resolution)
○ User Specified DEM

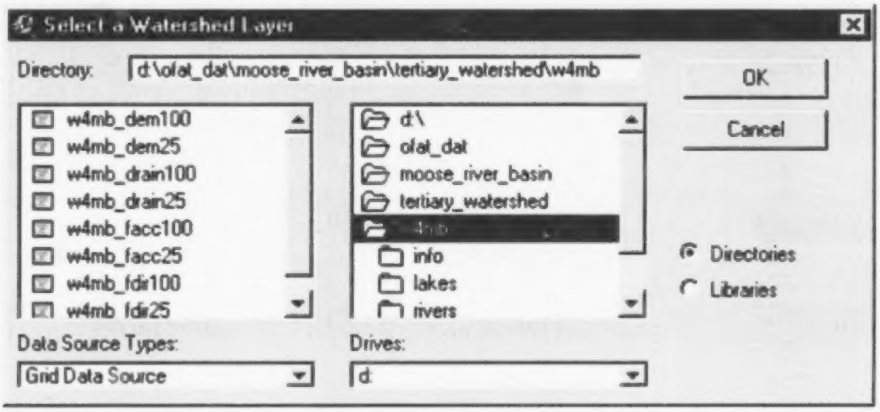
After the choice of DEM, a message box will appear with the projection information for the selected tertiary watershed.


OFAT Message: Import Information
OK

Please ensure that the watershed layer to be imported
is an ARC/INFO grid or a polygon shapefile
and is projected in UTM zone 17, NAD83 CNT.

! ***Warning***: *It is important that the imported watershed be in the appropriate projection for WIES to properly perform any information extraction.*

At this point the watershed layer selection menu will appear. If the layer to be imported is an ArcInfo grid, set the 'Data Source Types' to 'Grid Data Source'. This setting will only display grid layers in the file selection window. For shapefile layers, set the 'Data Source Types' to 'Feature Data Source'. Select a layer and click 'OK'.


Select a Watershed Layer
w4mb_dem100
w4mb_dem25
w4mb_drain100
w4mb_drain25
w4mb_facc100
w4mb_facc25
w4mb_fdir100
w4mb_fdir25
d:\
ofat_dat
moose_river_basin
tertiary_watershed
w4mb
info
lakes
rivers
OK
Cancel
● Directories
○ Libraries

Directory: d:\ofat_dat\moose_river_basin\tertiary_watershed\w4mb

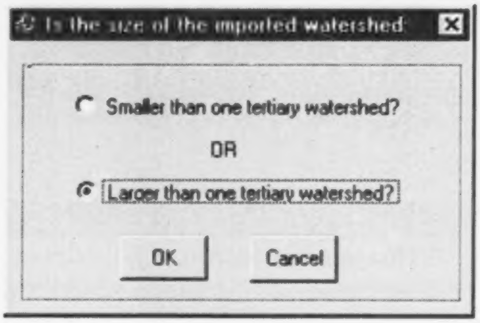
Data Source Types: Grid Data Source

Drives: d:

When the layer is selected it will be added to the 'Selected Watershed Area' map and the WIES component can be run.

Importing Watersheds Larger Than One Tertiary Watershed

When the 'Larger than one tertiary watershed?' option is selected, the process is the same as above, however the DEM selection is limited to 100m and 1km resolutions.


Is the size of the imported watershed:

○ Smaller than one tertiary watershed?

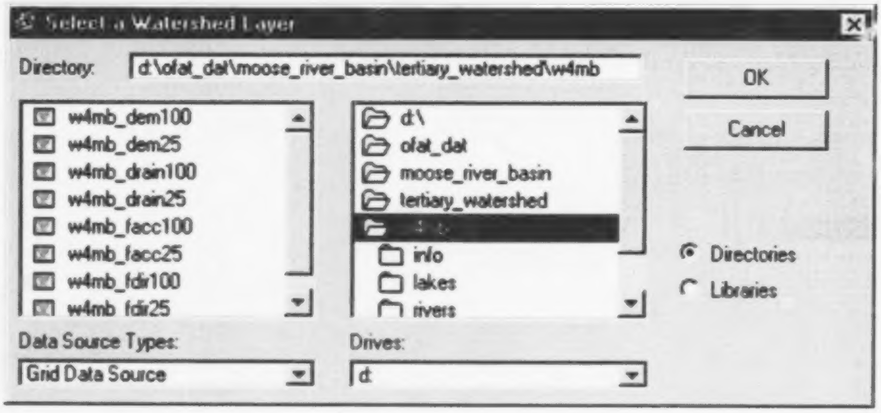
OR

● Larger than one tertiary watershed?

After the choice of DEM resolution, the DEM-related data will be merged, if necessary. This process may take time depending on the number of involved upstream tertiary watersheds. A message box will then appear with the projection information that should be used for the imported watershed layer.

! **Warning**: *It is important that the imported watershed be in the appropriate projection for WIES to properly perform any information extraction.*

At this point the layer selection menu will appear. If the layer to be imported is an ArcInfo grid, set the 'Data Source Types' to 'Grid Data Source'. This setting will only display grid layers in the file selection window. For shapefile layers, set the 'Data Source Types' to 'Feature Data Source'. Select a layer and click 'OK'.


Select a Watershed Layer

Directory: d:\ofat_dat\moose_river_basin\tertiary_watershed\w4mb

w4mb_dem100
w4mb_dem25
w4mb_drain100
w4mb_drain25
w4mb_facc100
w4mb_facc25
w4mb_fdir100
w4mb_fdir25

d:\
ofat_dat
moose_river_basin
tertiary_watershed
info
lakes
rivers

● Directories
○ Libraries

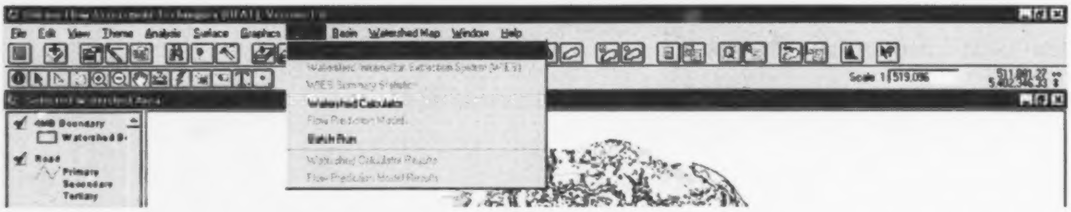
Data Source Types: Grid Data Source

Drives: d:

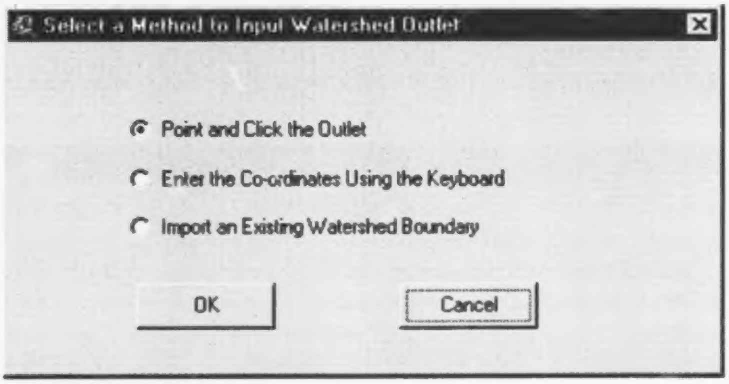
When the layer is selected it will be added to the 'Selected Watershed Area' map and the WIES component can be run.

Delineating a New Watershed

After a watershed has been delineated or imported, if a new watershed is needed within the same tertiary watershed, click the 'Delineate New Watershed' button. This option can also be accessed through the 'OFAT' pull down menu by clicking on the 'Watershed Delineation' item.


File
Edit
View
Theme
Analysis
Surface
Graphics
Basin
Watershed Map
Window
Help
Watershed Calculator
Flow Prediction Model
Batch Run
Watershed Calculator Results
Flow Prediction Model Results
Boundary
Watershed B
Road
Primary
Secondary
Tertiary
Scale 1:519,086

The following menu appears allowing the user to select a method of creating a new watershed.



Select a Method to Input Watershed Outlet

● Point and Click the Outlet

○ Enter the Co-ordinates Using the Keyboard

○ Import an Existing Watershed Boundary

! ***Warning**: New delineated watersheds will replace previous delineated watersheds. OFAT will not automatically save the boundary of the delineated watershed. Please follow the procedures outlined in this manual to save any results generated by OFAT, if they are needed for future use.*

Once a method has been selected, follow the steps previously described in this manual to create a new watershed.

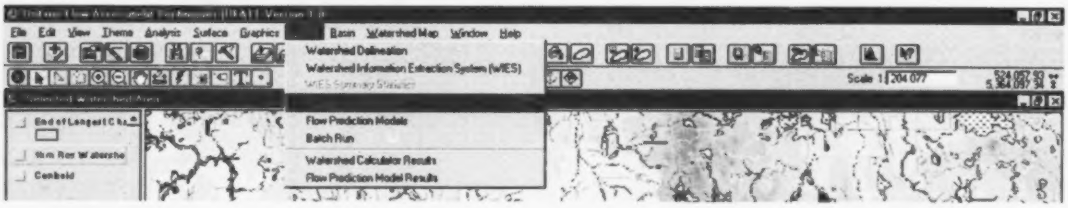
Watershed Calculator

Accessing the Watershed Calculator

The Watershed Calculator component allows the user to calculate a variety of hydrologic parameters for the delineated watershed currently in the 'Selected Watershed Area' map. After a watershed has been delineated, you can run the 'Watershed Calculator'.

There are two ways to access the 'Watershed Calculator' interface:

- Click the button on the toolbar.
- Open the 'OFAT' pull down menu, and then select the 'Watershed Calculator' menu item.


File
Edit
View
Theme
Analysis
Surface
Graphics
Basin
Watershed Map
Window
Help
Watershed Delineation
Watershed Information Extraction System (WIES)
WIES Summary Statistics
Flow Prediction Models
Batch Run
Watershed Calculator Results
Flow Prediction Model Results
Scale 1: 204 077
End of Longest Ch
Centroid

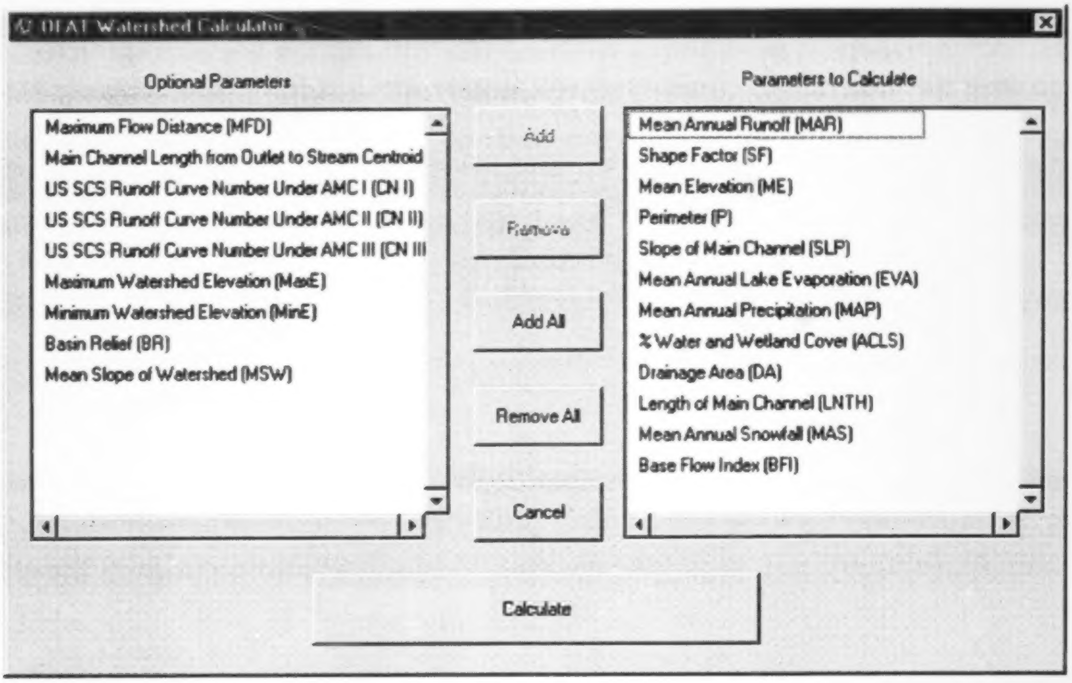
✎ ***Note****: The 'Watershed Calculator' button and menu item will only become available once a watershed has been delineated by OFAT. Currently, this feature is not available for watersheds that have been imported into OFAT.*

Watershed Calculator Parameters

The Watershed Calculator interface, as shown on the following page, consists of two list boxes for watershed parameters:

- 'Parameters to Calculate' – these include the watershed parameters required to calculate the flow models currently in OFAT. Required parameters cannot be removed from the list and will be calculated every time the Watershed Calculator is run.
- 'Optional Parameters' – these include watershed parameters that are not required to run the flow models currently in OFAT but provide the user with additional information about the watershed.

A description of each parameter, along with their units and symbols used in OFAT, can be found in Appendix B.


OFAT Watershed Calculator

Optional Parameters

Maximum Flow Distance (MFD)
Main Channel Length from Outlet to Stream Centroid
US SCS Runoff Curve Number Under AMC I (CN I)
US SCS Runoff Curve Number Under AMC II (CN II)
US SCS Runoff Curve Number Under AMC III (CN III
Maximum Watershed Elevation (MaxE)
Minimum Watershed Elevation (MinE)
Basin Relief (BR)
Mean Slope of Watershed (MSW)

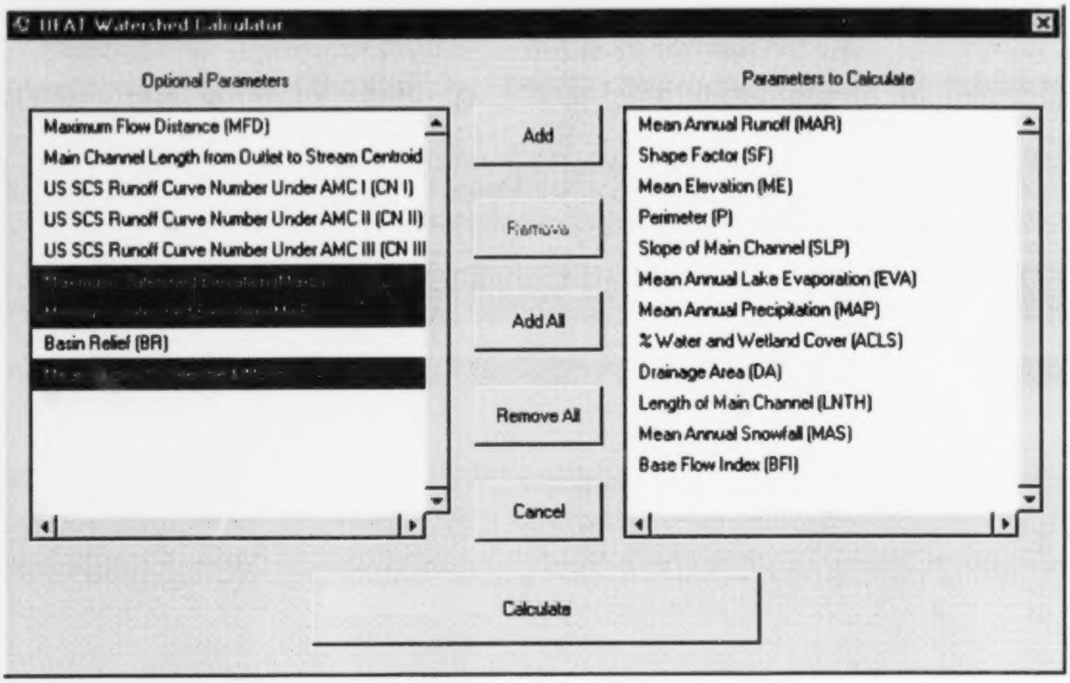
Parameters to Calculate

Mean Annual Runoff (MAR)
Shape Factor (SF)
Mean Elevation (ME)
Perimeter (P)
Slope of Main Channel (SLP)
Mean Annual Lake Evaporation (EVA)
Mean Annual Precipitation (MAP)
% Water and Wetland Cover (ACLS)
Drainage Area (DA)
Length of Main Channel (LNTH)
Mean Annual Snowfall (MAS)
Base Flow Index (BFI)

At any time, the 'Cancel' button can be used to close the Watershed Calculator interface and the user will be returned to the 'Selected Watershed Area' map.

Selecting the Parameters

The parameters listed in the 'Parameters to Calculate' list box will be automatically calculated when the user clicks the 'Calculate' button. To add optional parameters, choose the parameter(s) from the 'Optional Parameters' list box. Once a selection is made, the 'Add' button will become active. Clicking the 'Add' button will remove the selected parameters from the 'Optional Parameters' list box and move them to the 'Parameters to Calculate' list box. All of the parameters in the 'Optional Parameters' list box can be added to the 'Parameters to Calculate' list box by clicking on the 'Add All' button.



Optional Parameters

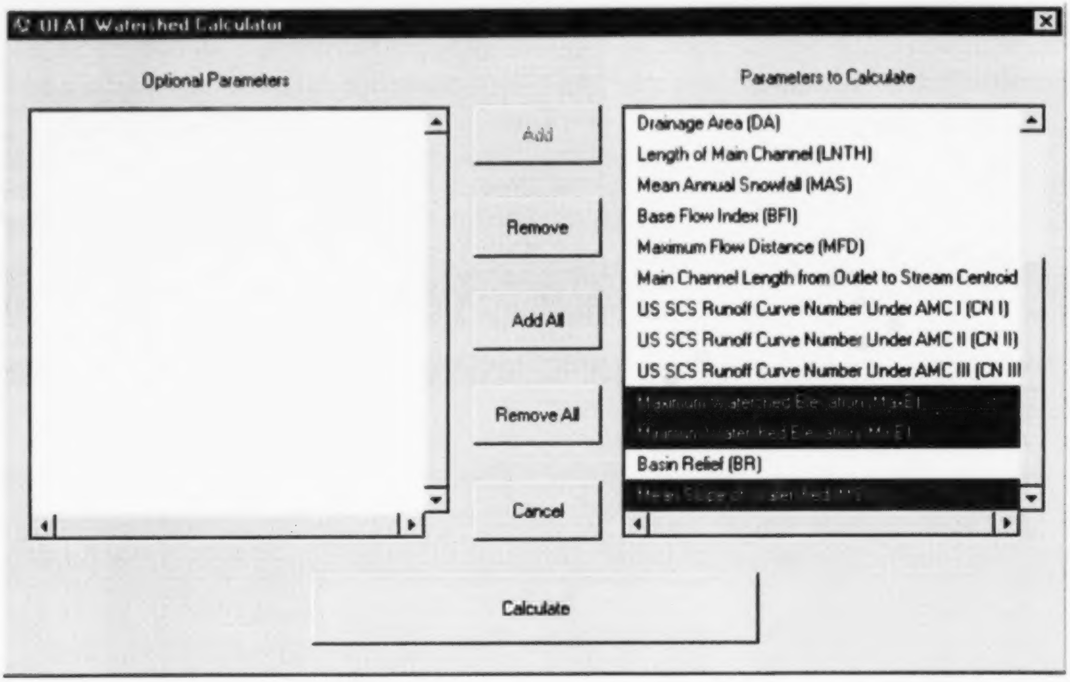
Maximum Flow Distance (MFD)
Main Channel Length from Outlet to Stream Centroid
US SCS Runoff Curve Number Under AMC I (CN I)
US SCS Runoff Curve Number Under AMC II (CN II)
US SCS Runoff Curve Number Under AMC III (CN III
[illegible]
[illegible]
Basin Relief (BR)
[illegible]

Parameters to Calculate

Mean Annual Runoff (MAR)
Shape Factor (SF)
Mean Elevation (ME)
Perimeter (P)
Slope of Main Channel (SLP)
Mean Annual Lake Evaporation (EVA)
Mean Annual Precipitation (MAP)
% Water and Wetland Cover (ACLS)
Drainage Area (DA)
Length of Main Channel (LNTH)
Mean Annual Snowfall (MAS)
Base Flow Index (BFI)

Removing the Parameters

To remove optional parameters from the 'Parameters to Calculate' list box, choose the parameters to remove. Once a selection is made, the 'Remove' button will become active. Clicking 'Remove' will clear the selected parameters from the 'Parameters to Calculate' list box and return them to the 'Optional Parameters' list box. All of the optional parameters can be cleared by clicking 'Remove All'.


OFAT Watershed Calculator
Optional Parameters
Parameters to Calculate
Add
Remove
Add All
Remove All
Cancel
Drainage Area (DA)
Length of Main Channel (LNTH)
Mean Annual Snowfall (MAS)
Base Flow Index (BFI)
Maximum Flow Distance (MFD)
Main Channel Length from Outlet to Stream Centroid
US SCS Runoff Curve Number Under AMC I (CN I)
US SCS Runoff Curve Number Under AMC II (CN II)
US SCS Runoff Curve Number Under AMC III (CN III
Maximum Watershed Elevation (MaxEl)
Minimum Watershed Elevation (MinEl)
Basin Relief (BR)
Mean Slope of Watershed (MS)
Calculate

Running the Watershed Calculator

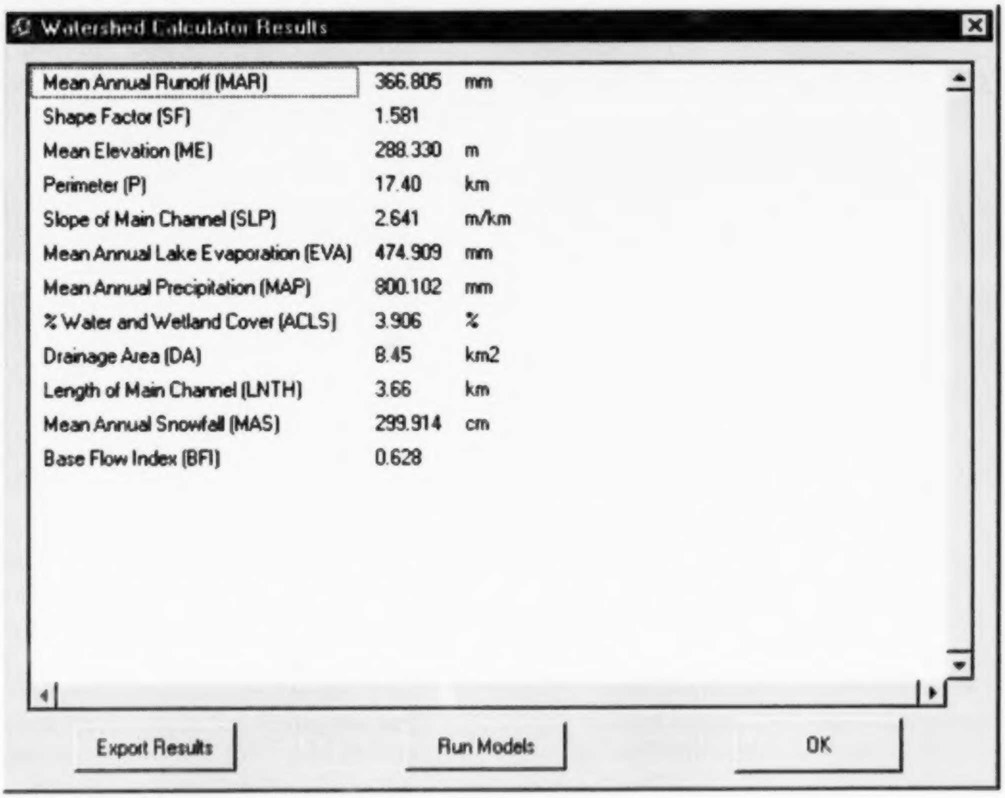
To run the calculation for the watershed parameters chosen in the 'Parameters to Calculate' list box, click 'Calculate'. While the parameters are being calculated, two new data layers (i.e., 'End of Longest Channel' and '1km Res. Watershed') are created and added to the 'Selected Watershed Area' map. These two layers are needed when calculating some of the parameters and running some of flow models. Do not remove them from the map.

✎ ***Note**: Some parameters may take longer to calculate if finer resolution DEMs are selected. Please exercise patience when calculating parameters using the 10m and 20m resolution DEMs.*

✎ ***Note**: The 'Selected Watershed Area' map will refresh multiple times while calculating parameters. Please wait until the 'Watershed Calculator Results' window appears before continuing.*

Watershed Calculator Results

When the selected parameters have been calculated, the results will be displayed in the 'Watershed Calculator Results' window.



Mean Annual Runoff (MAR)	366.805	mm
Shape Factor (SF)	1.581	
Mean Elevation (ME)	288.330	m
Perimeter (P)	17.40	km
Slope of Main Channel (SLP)	2.641	m/km
Mean Annual Lake Evaporation (EVA)	474.909	mm
Mean Annual Precipitation (MAP)	800.102	mm
% Water and Wetland Cover (ACLS)	3.906	%
Drainage Area (DA)	8.45	km2
Length of Main Channel (LNTH)	3.66	km
Mean Annual Snowfall (MAS)	299.914	cm
Base Flow Index (BFI)	0.628	

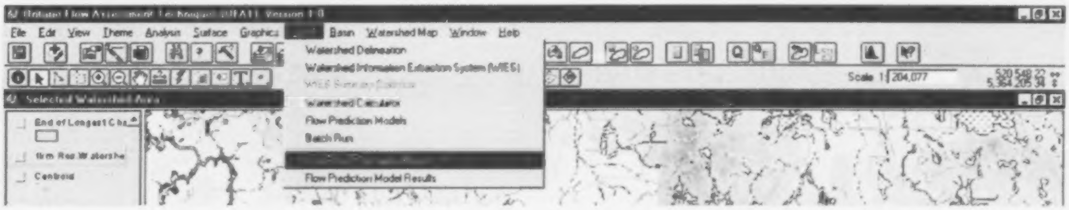
To save the results of calculation, click the 'Export Results' button which will be described later in the manual.

! ***Warning**: Running the 'Watershed Calculator' again for another delineated watershed will replace the calculation results of previous watershed.*

At this point, the user can run flow models by clicking 'Run Models'. This will close the 'Watershed Calculator Results' window and open the 'Flow Prediction Models' interface that will be described later in the manual.

When finished viewing the results, close the window by clicking 'OK' or by clicking the **X** in the top right hand corner of the window. This will return the user to the 'Selected Watershed Area' map.

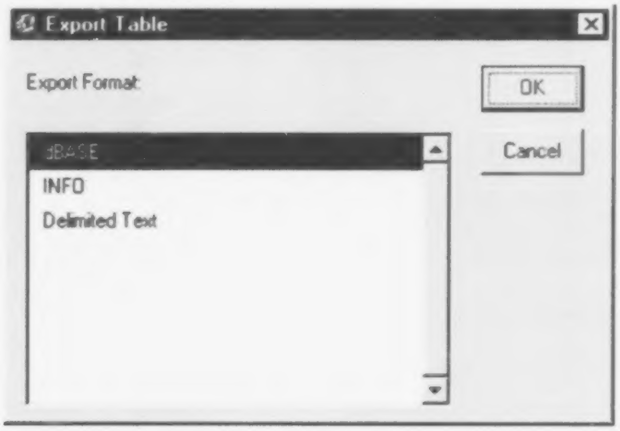
To open the 'Watershed Calculator Results' window at anytime after the Watershed Calculator has been run, click the ▤ button in the toolbar or select the 'Watershed Calculator Results' item under the 'OFAT' pull down menu.


File
Edit
View
Theme
Analysis
Surface
Graphics
Basin
Watershed Map
Window
Help
Watershed Delineation
Watershed Information Extraction System (WIES)
Watershed Calculator
Flow Prediction Models
Batch Run
Flow Prediction Model Results
Selected Watershed Area
End of Longest Cha
Centroid
Scale 1:204,077

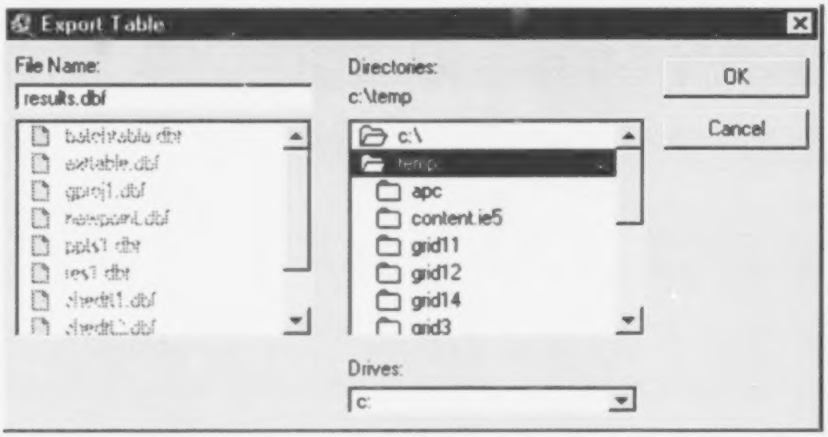
The button and menu option will only become active after the 'Watershed Calculator' has been run. If another watershed is delineated, these options will become inactive and all the calculated parameter results for the previous watershed will be replaced.

Exporting Watershed Calculator Results

From the 'Watershed Calculator Results' window, the calculation results of watershed parameters can be exported to a table. Clicking the 'Export Results' button will open a window that prompts the user to select the type of file to be created in the export process.


Export Table
Export Format:
OK
Cancel
dBASE
INFO
Delimited Text

After the choice of file format is made, click 'OK'. The following 'Export Table' window will appear where the file name and path can be entered. A default name will appear in the 'File Name:' text box, but this can be changed. Once the file name and path are specified, click 'OK' to start exporting.



Export Table

File Name: results.dbf

Directories: c:\temp

Drives: c:

At any time, the user can click 'Cancel' button to stop the export process. This will return the user to the 'Watershed Calculator Results' window.

Using OFAT for Flow Prediction: Hydrologic Modelling

This chapter will introduce the flow models included in OFAT, and describe the procedures used to generate and report various flow modelling results.

OFAT contains a number of regional hydrologic models and empirical relationships that generate flow information. After a watershed is delineated and the required watershed parameters/information are calculated/extracted, various flow regimes can be generated for the watershed.

Introduction of Flow Models in OFAT

OFAT currently contains five flow model categories, as listed below. Each category contains a number of models. Please see Appendix D for a brief description of each of the models currently in OFAT. The limitations of each model, if mentioned in the original literature, are also included in the Appendix. For details about each individual model, please refer to its original literature listed in the References section.

1. Low Flow Prediction Models (LOF)

   This type of model generates low flow such as mQ_n representing m-day low flow in a n-year return period. For example, $7Q_{20}$ represents the 7-day low flow in a 20-year return period.

   - Isoline Method (MOEE, 1995)
   - Graphical Index Method (MOEE, 1995)
   - Statistical Index Method (MOEE, 1995)
   - Regression Method (MOEE, 1995)

2. Flood Prediction Models (HIF)

   This type of model generates flood flows such as Q_n representing flood in a n-year return period. For example, Q_{10} represents the flood in a ten-year return period.

   - Index Flood Method (Moin & Shaw, 1985)
   - Index Flood Method With Expected Probability Adjustment (Moin & Shaw, 1985)
   - Primary Multiple Regression Method (Moin & Shaw, 1985)
   - Secondary Multiple Regression Method (Moin & Shaw, 1985)
   - Multiple Regression Method (MNR, 2000)
   - Dimensionless Flood Frequency Method (MNR, 2000)
   - Regional Flood Frequency Method (MNR, 2000)
   - Isoline Method (MNR, 2000)

3. Mean Annual Flow Prediction Model (MAF)

   This type of model generates the mean annual flow for the watershed.

   - Isoline Method (Environment Canada, 1986)

4. Minimum Instream Flow Requirement Models (IFR)

   This type of model relates mean annual flow to the flow ranges rated by the degree to which aquatic resources are protected. Flow ratings include flushing to maximum, optimal, outstanding, excellent, good, fair or degrading, poor or minimum, and severe degradation.
   - Montana Method - April to September (Tennant, 1976)
   - Montana Method - October to March (Tennant, 1976)

5. Bankfull Discharge Prediction Model (BFQ)

   Generally, this type of model relates the bankfull discharge to floods occurring in a 1- to 2-year return period.
   - Annable Bankfull Discharge Model (Annable, 1994)
   - Leopold Bankfull Discharge Model (Leopold *et al.*, 1964)
   - Dury Bankfull Discharge Model (Dury, 1973)

The user can select several models from different model categories, and then execute them in the same run. This allows the user to compare the results from a variety of models (e.g., Isoline Method versus Regression Method of Low Flow Prediction Model). After the selected flow models are executed, OFAT reports the results of flow information for the delineated watershed.

✎ ***Note****: Most models included in OFAT are regional hydrologic models. To estimate flows for a watershed, OFAT uses an appropriate map (e.g., low flow regions map, flood regions map) to determine automatically which region or sub-region the watershed is located. Then, appropriate sets of equations/relationships are used to calculate desired flow information.*

! ***Warning****: Each flow model in OFAT has its own limitations. This means that the models included in OFAT should only be used for a watershed within the ranges of the parameters (e.g., drainage area) that were originally used for developing the models. Use of the equations/relationships is not encouraged outside of their parameter ranges. For example, using the Regression Method (MOEE, 1995) in the low flow category for a small watershed would likely generate incorrect "negative" low flow values. It is strongly suggested that the original model document be referred to, or consult with a water professional, before using generated flow values for any decision making purpose.*

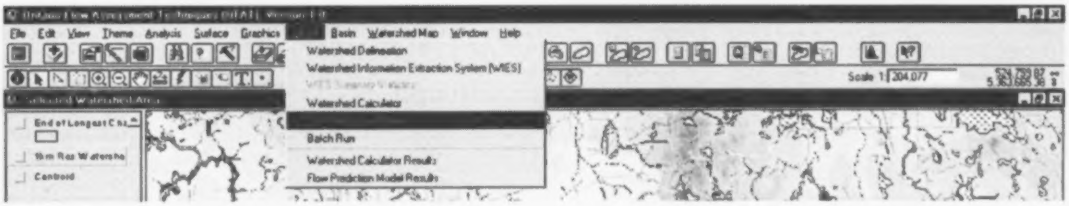
Accessing the Model Interface

Flow models in OFAT calculate flow values for the current delineated watershed shown in the 'Selected Watershed Area' map.

The model interface can be accessed at any time after the 'Watershed Calculator' has been run. There are three ways available to access this interface:

- Click the 'Run Models' button on the 'Watershed Calculator Results' window.
- Click the Q button in the toolbar.
- Select 'Flow Prediction Models' item found in the 'OFAT' pull down menu.

✎ ***Note**: OFAT does not currently have the functionality to run the flow prediction models for imported watersheds.*


File
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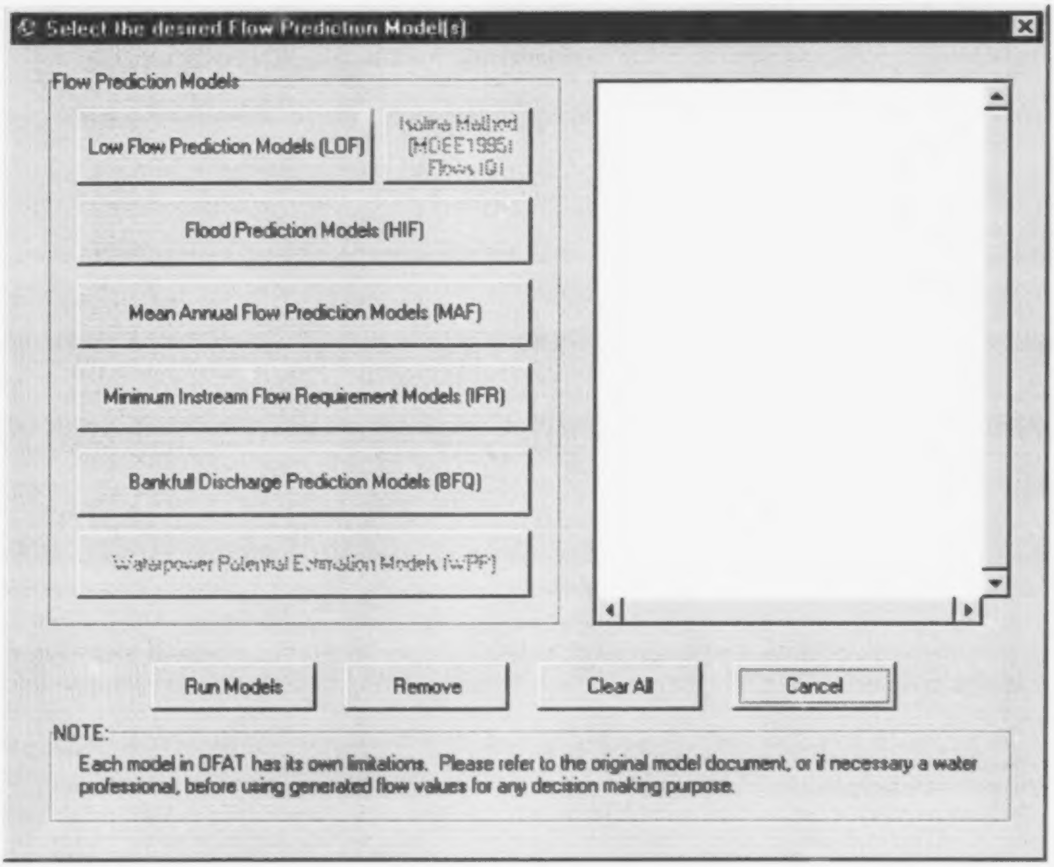
Surface
Graphics
Basin
Watershed Map
Window
Help
Watershed Delineation
Watershed Information Extraction System (WIES)
Watershed Calculator
Batch Run
Watershed Calculator Results
Flow Prediction Model Results
Scale 1:204,077
End of Longest Ch...
Centroid

✎ ***Note**: The Q button and 'Flow Prediction Models' pull down menu item are only active if a watershed has been delineated and watershed parameters have been calculated. If another watershed is delineated, Flow Prediction Models will be unavailable until the 'Watershed Calculator' is run for the newly delineated watershed.*

The Flow Prediction Models Interface

The 'Flow Prediction Models' interface consists of five model category buttons and a list box for model selections.


Select the desired Flow Prediction Model(s)
Flow Prediction Models
Low Flow Prediction Models (LOF)
Isoline Method (MOEE1995) Flows (Q)
Flood Prediction Models (HIF)
Mean Annual Flow Prediction Models (MAF)
Minimum Instream Flow Requirement Models (IFR)
Bankfull Discharge Prediction Models (BFQ)
Waterpower Potential Estimation Models (WPP)
Run Models
Remove
Clear All
Cancel
NOTE:

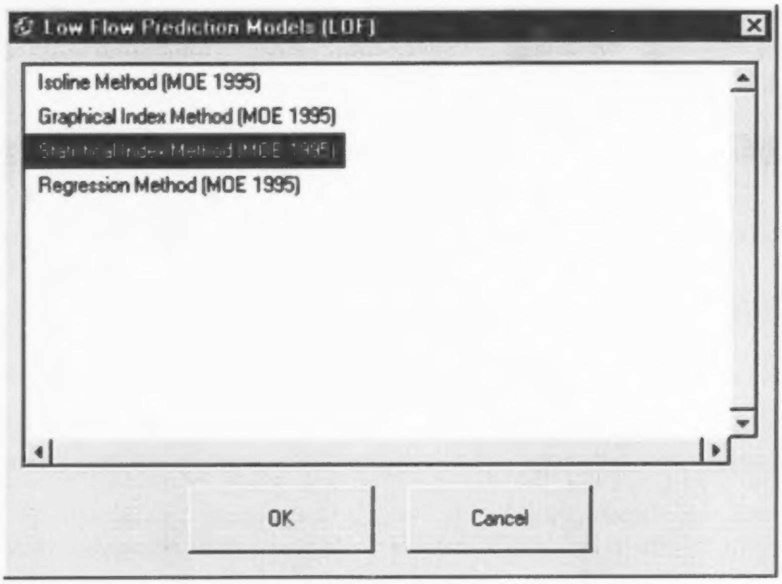
Each model in OFAT has its own limitations. Please refer to the original model document, or if necessary a water professional, before using generated flow values for any decision making purpose.

✎ ***Note***: *The 'Waterpower Potential Estimation Models (WPP)' category is not available at present.*

By clicking on any of the categories, a selection menu will be displayed containing the available models for the selected category.

At any time, the 'Cancel' button can be used to close the 'Flow Prediction Models' interface and return the user to the 'Selected Watershed Area' map.

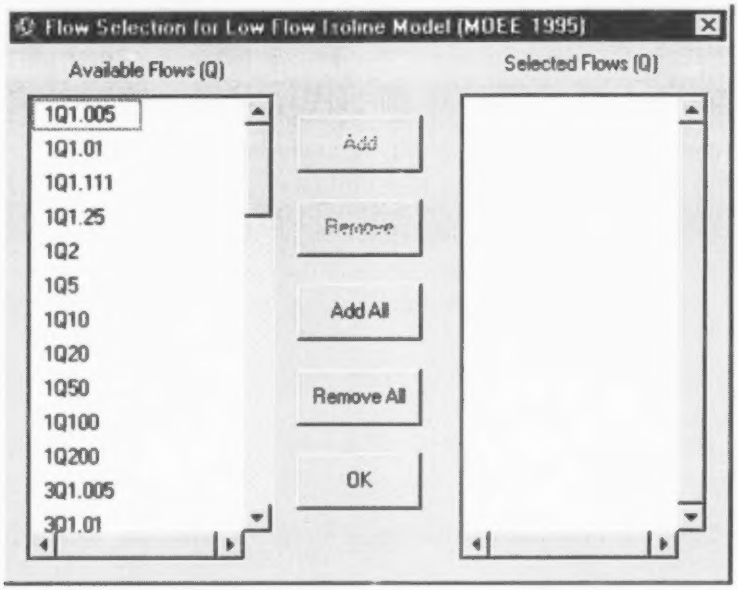
Selecting Models


Low Flow Prediction Models (LOF)
Isoline Method (MOE 1995)
Graphical Index Method (MOE 1995)
Statistical Index Method (MOE 1995)
Regression Method (MOE 1995)
OK
Cancel

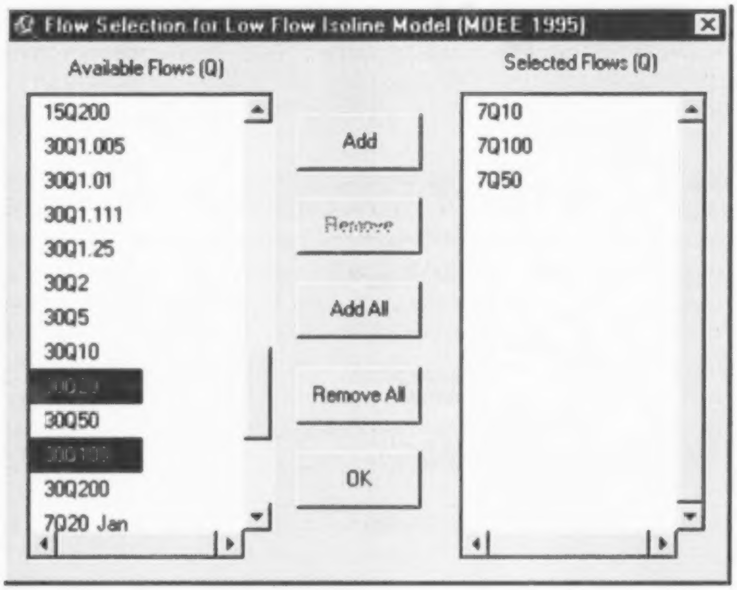
To select a flow model under the selected category, click on the model you wish to run. For multiple selections, press and hold down the SHIFT key and select the desired models. When complete, click 'OK' to return to the main 'Flow Prediction Models' interface. The models that were selected will be added and displayed in the list box on the interface. Clicking 'Cancel' will return to the 'Flow Prediction Models' interface, but will not add any of the selected models to the list box.

Selecting Low Flows for the Isoline Method (MOEE, 1995)

Since the Isoline Method (MOEE, 1995) has more flow scenarios to select from than any other model in OFAT, choosing this method opens a separate flow selection interface. This interface allows the selection of different low flows to be estimated by this particular method.


Flow Selection for Low Flow Isoline Model (MOEE 1995)
Available Flows (Q)
Selected Flows (Q)
1Q1.005
1Q1.01
1Q1.111
1Q1.25
1Q2
1Q5
1Q10
1Q20
1Q50
1Q100
1Q200
3Q1.005
3Q1.01
Add
Remove
Add All
Remove All
OK

The Isoline Method (MOEE, 1995) has 67 low flows to choose from. Select the appropriate low flows from the 'Available Flows (Q)' list on the left. When a flow has been selected, the 'Add' button will become active. Click 'Add' to add the flows to the 'Selected Flows (Q)' list on the right.

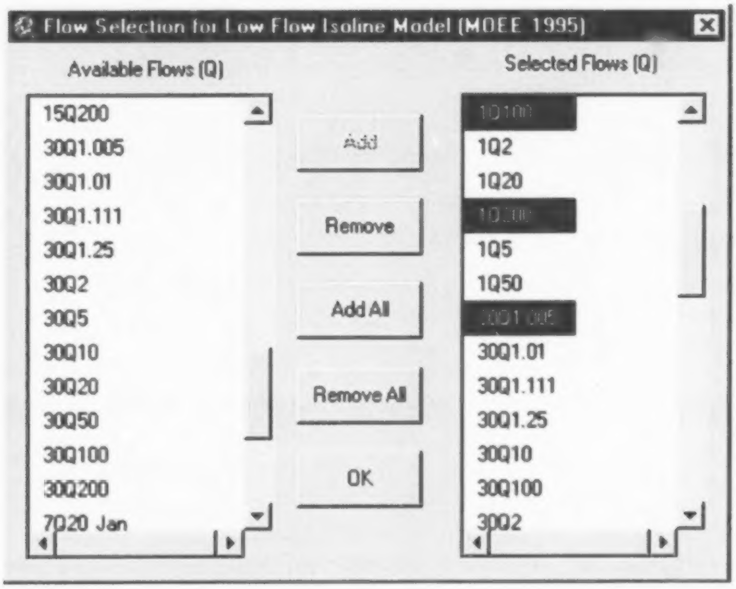

Flow Selection for Low Flow Isoline Model (MOEE 1995)
Available Flows (Q)
Selected Flows (Q)
15Q200
30Q1.005
30Q1.01
30Q1.111
30Q1.25
30Q2
30Q5
30Q10
30Q20
30Q50
30Q100
30Q200
7Q20 Jan
Add
Remove
Add All
Remove All
OK
7Q10
7Q100
7Q50

To make multiple selections from the 'Available Flows (Q)' list, hold down the SHIFT key and select the flows. Using the 'Add All' button will add every item in the 'Available Flows (Q)' list to the 'Selected Flows (Q)' list.

To remove items from the 'Selected Flows (Q)' list, highlight the flows you want to remove and click the 'Remove' button.

✎ **Note**: *The 'Remove' button only becomes active after an item is selected in the 'Selected Flows (Q)' list. As with the 'Available Flows (Q)' list, multiple selections can be made by holding down the SHIFT key and selecting the flows. To clear all entries in the 'Selected Flows (Q)' list, click 'Remove All'.*

When all the desired flows in the 'Available Flows (Q)' list have been added to the 'Selected Flows (Q)' list, click 'OK'. This will return to the main 'Flow Prediction Models' interface.


Flow Selection for Low Flow Isoline Model (MOEE 1995)
Available Flows (Q)
15Q200
30Q1.005
30Q1.01
30Q1.111
30Q1.25
30Q2
30Q5
30Q10
30Q20
30Q50
30Q100
30Q200
7Q20 Jan
Add
Remove
Add All
Remove All
OK
Selected Flows (Q)
1Q100
1Q2
1Q20
1Q200
1Q5
1Q50
30Q1.005
30Q1.01
30Q1.111
30Q1.25
30Q10
30Q100
30Q2

The Isoline Method (MOEE, 1995) is added to the list box on the main 'Flow Prediction Models' interface. If you would like to make changes to the flows selected for this method, you can access the above interface directly through the 'Flow Prediction Models' interface by clicking the following button.

Isoline Method
(MOEE1995)
Flows (Q)

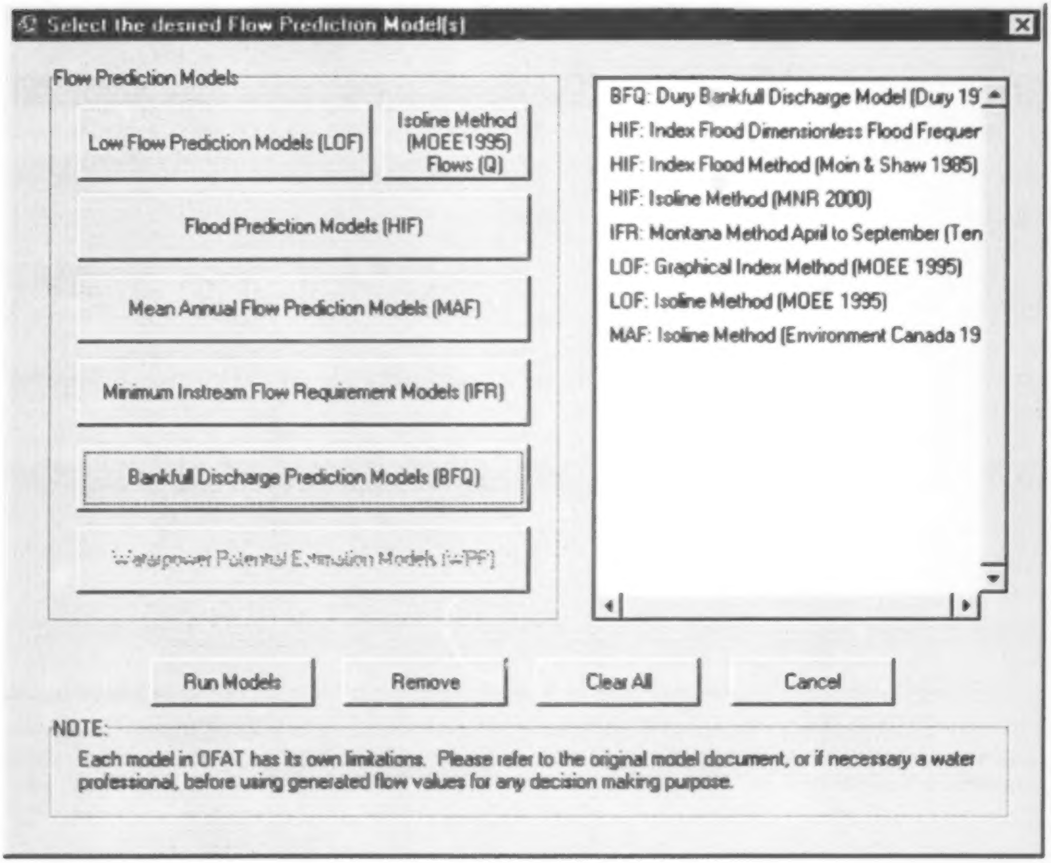
If there are no selections made for the Isoline Method (MOEE, 1995), clicking 'OK' will remove this method from the list box on the 'Flow Prediction Models' interface and the button, shown above, will be dimmed out.

Removing Models

In the 'Flow Prediction Models' interface, models can be deleted from the list box by selecting the model and clicking 'Remove'.

✎ ***Note:*** *In the list box on the 'Flow Prediction Models' interface, multiple selection is not available. Models may only be removed from the list box one at a time.*

To remove all the models from the list box at once, click 'Clear All'.


Select the desired Flow Prediction Model(s)
Flow Prediction Models
Low Flow Prediction Models (LOF)
Isoline Method (MOEE1995) Flows (Q)
Flood Prediction Models (HIF)
Mean Annual Flow Prediction Models (MAF)
Minimum Instream Flow Requirement Models (IFR)
Bankfull Discharge Prediction Models (BFQ)
Waterpower Potential Estimation Models (WPF)
Run Models
Remove
Clear All
Cancel

BFQ: Duxy Bankfull Discharge Model (Duxy 19
HIF: Index Flood Dimensionless Flood Frequer
HIF: Index Flood Method (Moin & Shaw 1985)
HIF: Isoline Method (MNR 2000)
IFR: Montana Method April to September (Ten
LOF: Graphical Index Method (MOEE 1995)
LOF: Isoline Method (MOEE 1995)
MAF: Isoline Method (Environment Canada 19

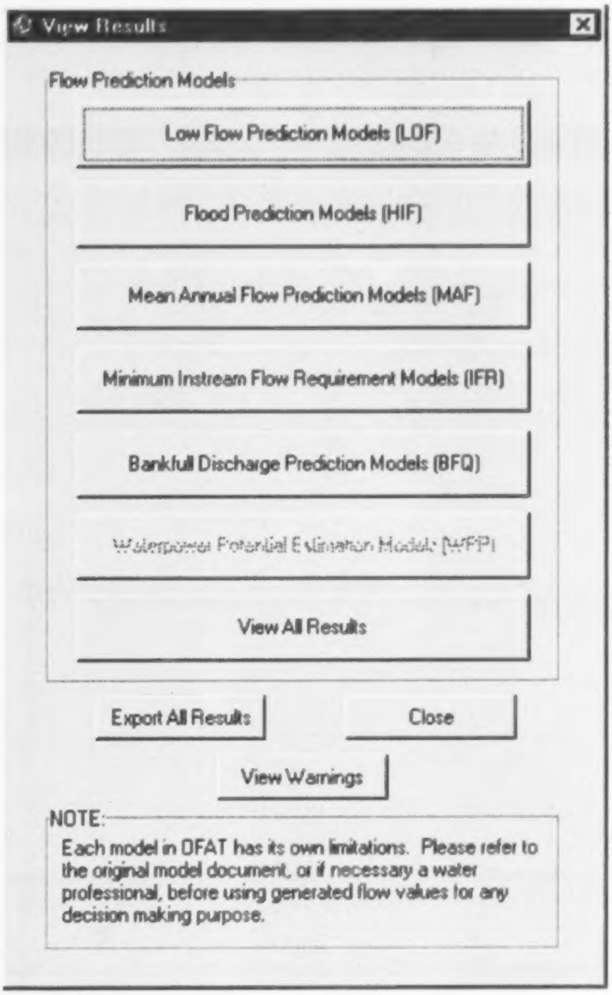
NOTE:
Each model in OFAT has its own limitations. Please refer to the original model document, or if necessary a water professional, before using generated flow values for any decision making purpose.

Running Models

To run the selected models, click 'Run Models' on the 'Flow Prediction Models' interface. When the models have finished processing, the 'View Results' menu will open.

Viewing the Flow Model Results

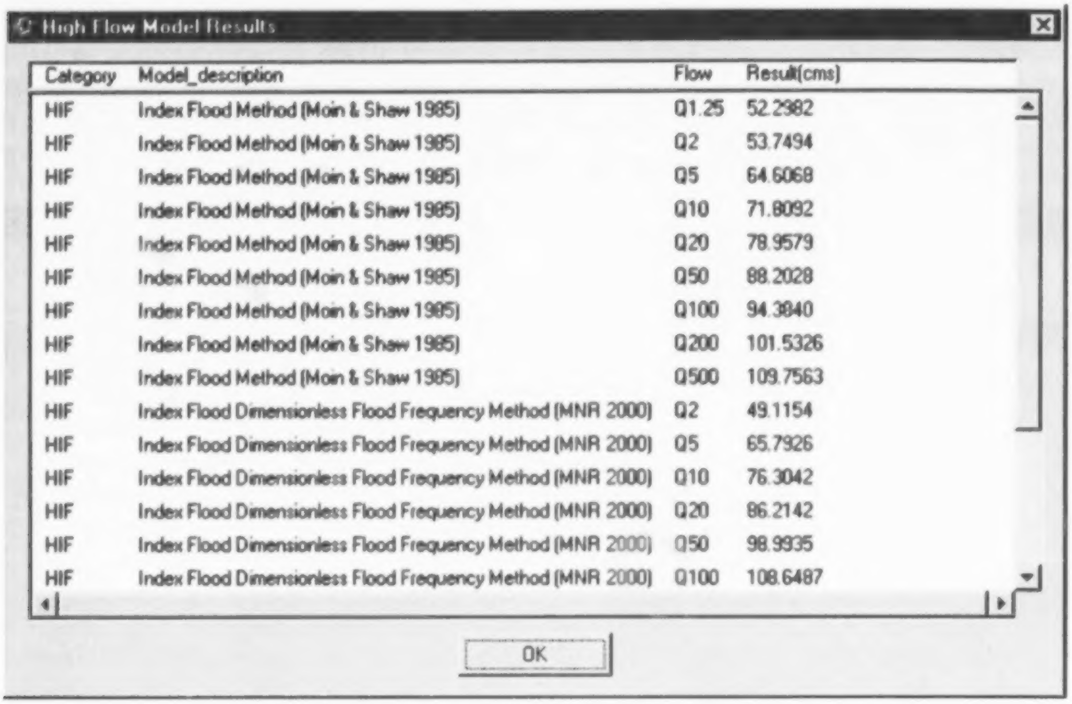
The 'View Results' menu is divided into the five model categories similar to the 'Flow Prediction Models' interface. When a flow model from a specific category has been executed, the corresponding button will be active.


View Results
Flow Prediction Models
Low Flow Prediction Models (LOF)
Flood Prediction Models (HIF)
Mean Annual Flow Prediction Models (MAF)
Minimum Instream Flow Requirement Models (IFR)
Bankfull Discharge Prediction Models (BFQ)
Waterpower Potential Estimation Models (WPP)
View All Results
Export All Results
Close
View Warnings
NOTE:

Each model in OFAT has its own limitations. Please refer to the original model document, or if necessary a water professional, before using generated flow values for any decision making purpose.

To view the model results, click on the category button in the 'View Results' menu. This will open the 'Model Results' window.

The 'View All Results' button on the 'View Results' menu will allow you to see all the modelling results in the same window.


High Flow Model Results
OK

Category	Model_description	Flow	Result(cms)
HIF	Index Flood Method (Moin & Shaw 1985)	Q1.25	52.2982
HIF	Index Flood Method (Moin & Shaw 1985)	Q2	53.7494
HIF	Index Flood Method (Moin & Shaw 1985)	Q5	64.6068
HIF	Index Flood Method (Moin & Shaw 1985)	Q10	71.8092
HIF	Index Flood Method (Moin & Shaw 1985)	Q20	78.9579
HIF	Index Flood Method (Moin & Shaw 1985)	Q50	88.2028
HIF	Index Flood Method (Moin & Shaw 1985)	Q100	94.3840
HIF	Index Flood Method (Moin & Shaw 1985)	Q200	101.5326
HIF	Index Flood Method (Moin & Shaw 1985)	Q500	109.7563
HIF	Index Flood Dimensionless Flood Frequency Method (MNR 2000)	Q2	49.1154
HIF	Index Flood Dimensionless Flood Frequency Method (MNR 2000)	Q5	65.7926
HIF	Index Flood Dimensionless Flood Frequency Method (MNR 2000)	Q10	76.3042
HIF	Index Flood Dimensionless Flood Frequency Method (MNR 2000)	Q20	86.2142
HIF	Index Flood Dimensionless Flood Frequency Method (MNR 2000)	Q50	98.9935
HIF	Index Flood Dimensionless Flood Frequency Method (MNR 2000)	Q100	108.6487

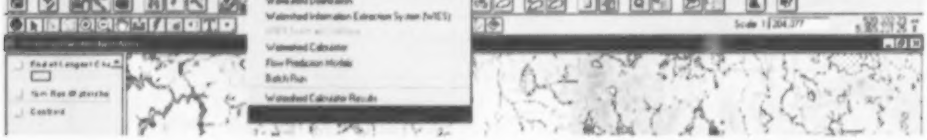
The 'Model Results' window shows the title of the model category in the header of the window (e.g., High Flow Model Results). The window displays four columns of information about the models:

- *Category*: the three letter short form used to identify different model categories (e.g., HIF)
- *Model Description*: a descriptive name for each model
- *Flow*: the flow being calculated (e.g., Q_5, $7Q_{30}$)
- *Result*: the flow result calculated by the model in cubic meters per second (cms)

Clicking 'OK' will close the window and return the user to the 'View Results' menu.

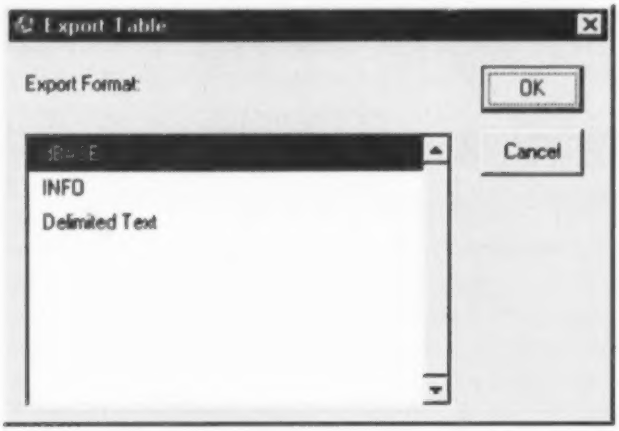
To close the 'View Results' menu, click 'Close'. However, if at any time after a model has been executed, and before another watershed is imported or delineated, the 'View Results' menu can be accessed using one of two methods:

- Clicking the 'Flow Prediction Model Results' button 🔍
- Opening the 'OFAT' pull down menu and clicking the 'Flow Prediction Model Results' item

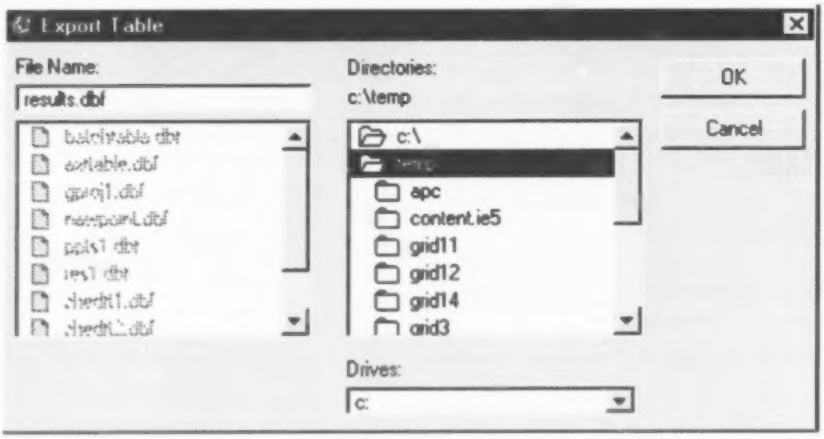

File Edit View Theme Analysis Surface Graphics
Basin Watershed Map Window Help
Watershed Delineation
Watershed Information Extraction System (WIES)
Watershed Calculator
Flow Prediction Models
Batch Run
Watershed Calculator Results

Exporting Flow Model Results

OFAT allows you to export the flow modelling results into a table by clicking the 'Export All Results' button on the 'View Results' menu. The 'Export Table' menu appears prompting the user to select the file type to be created in the export process.


Export Table
Export Format:
dBASE
INFO
Delimited Text
OK
Cancel

After the choice of file type is made, click 'OK'. The 'Export Table' window (shown below) will appear where the file name and path can be entered. A default name will appear in the 'File Name:' text box, but this can be changed. Once the file name and path are specified, click 'OK' to start the export process.


File Name: results.dbf

Directories: c:\temp

Drives: c:

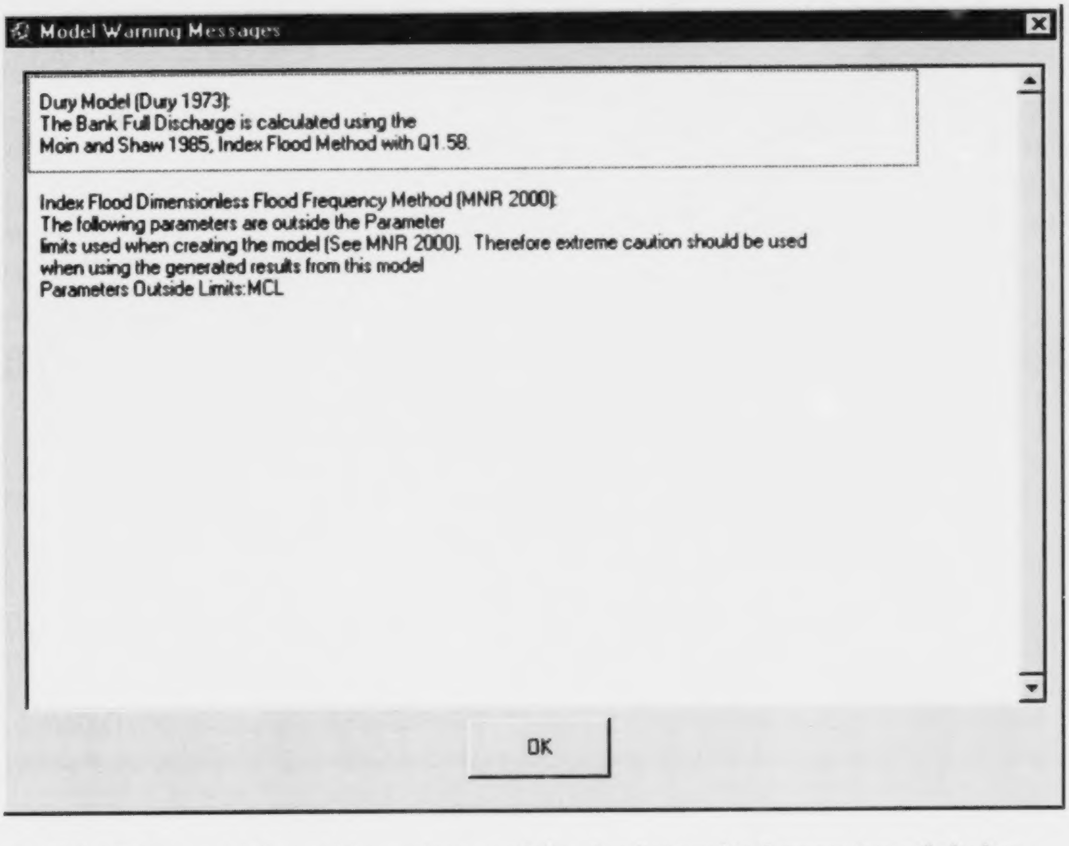
Export Table
c:\
temp
apc
content.ie5
grid11
grid12
grid14
grid3
OK
Cancel

Model Warnings

Each flow model within OFAT was originally developed to work within a range of watershed parameters (e.g., drainage area). If the parameters for a delineated watershed are outside the limitations of a selected model, a 'Model Warning Messages' window will appear after the models have been run. The information within these warning messages includes the model where a specific parameter(s) may not meet the criteria of the parameter ranges, and the watershed parameter(s) that is outside these ranges. Please read these warnings carefully. Extra information pertaining to the limits of each model can be found within the original model documents listed in the References.

The 'Model Warning Messages' window will also be shown when one model uses another model to find flow information. In these cases, the warning will include the models used. The following figure contains an example warning message for the Dury Model (Dury, 1973) in which $Q_{1.58}$ is used to estimate the bankfull discharge and is calculated using the Index Flood Method (Moin and Shaw, 1985).

After the warnings window has been closed by clicking 'OK', it can be accessed at any time from the 'View Results' menu by clicking on the 'View Warnings' button.



Dury Model (Dury 1973):
The Bank Full Discharge is calculated using the
Moin and Shaw 1985, Index Flood Method with Q1.58.

Index Flood Dimensionless Flood Frequency Method (MNR 2000):
The following parameters are outside the Parameter
limits used when creating the model (See MNR 2000). Therefore extreme caution should be used
when using the generated results from this model
Parameters Outside Limits:MCL

***Note**: Please read the model warnings carefully. Professional judgement is needed when using flow values derived with parameters outside the specified model limitations.*

Watershed Information Extraction System (WIES)

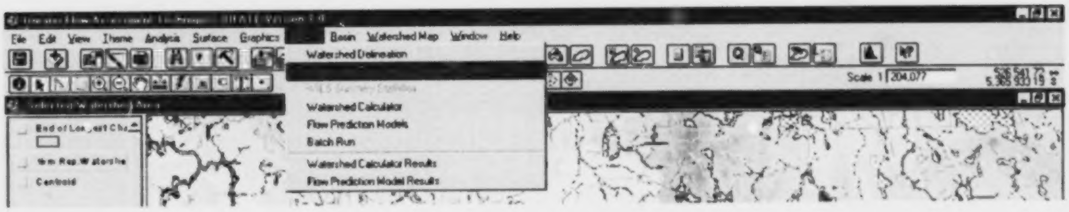
The Watershed Information Extraction System (WIES) is a component within OFAT that extracts and summarizes information from user-selected data layers for the delineated watershed. At this time, this is the only component in OFAT that can be used with an imported watershed.

Using WIES

WIES becomes available when the 'Selected Watershed Area' map is open and a watershed has been delineated or imported.

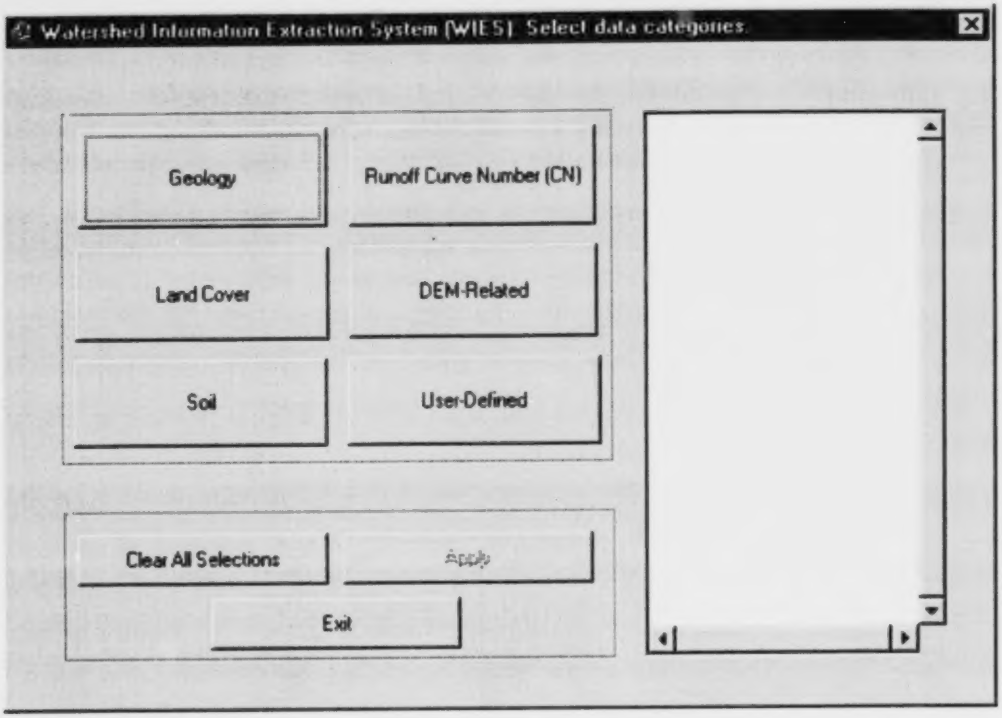
There are two ways to access the WIES component:

- Clicking the 'WIES' button on the toolbar; or
- Selecting the 'Watershed Information Extraction System (WIES)' item from the 'OFAT' pull down menu.


File
Edit
View
Theme
Analysis
Surface
Graphics
Basin
Watershed Map
Window
Help
Watershed Delineation
Watershed Calculator
Flow Prediction Models
Batch Run
Watershed Calculator Results
Flow Prediction Model Results
Scale 1:204,077
Centroid

WIES Menus and Selections

When WIES is opened, the following WIES main menu appears. The data layers have been grouped into six categories, each represented by a button on the menu. The 'OFAT Data Structure' chapter in this manual explains the data in more detail.

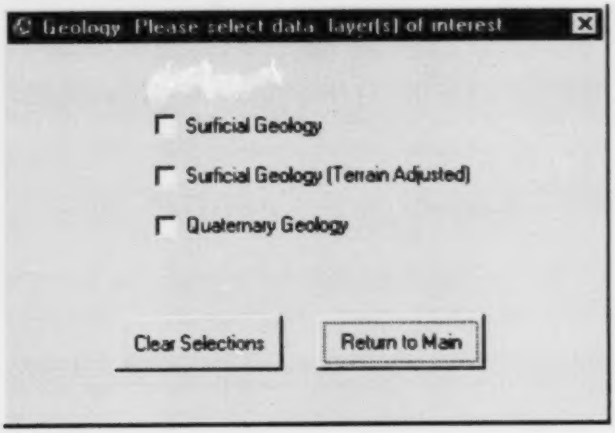

Watershed Information Extraction System (WIES): Select data categories.
Geology
Runoff Curve Number (CN)
Land Cover
DEM-Related
Soil
User-Defined
Clear All Selections
Apply
Exit

The following lists the data layers and data type within each category:

- Geology
  - Surficial Geology – coverage
  - Surficial Geology (Terrain Adjusted) – coverage
  - Quaternary Geology – coverage
- Land Cover
  - Land Cover (28 Classes) – ArcInfo grid
- Soil
  - Soil Landscapes of Canada – coverage
  - Ontario Land Inventory – coverage
- Runoff Curve Number (CN)
  - CN_I (Dry AMC) – calculation based on CN_{II} grid
  - CN_{II} (Average AMC) – ArcInfo grid
  - CN_{III} (Wet AMC) – calculation based on CN_{II} grid
- DEM-Related
  - Digital Elevation Model (DEM) – ArcInfo grid
  - Slope – ArcInfo grid
  - Aspect – ArcInfo grid
- User-Defined
  - User-Defined Layer 1 to 4 – ArcInfo grid or shapefile

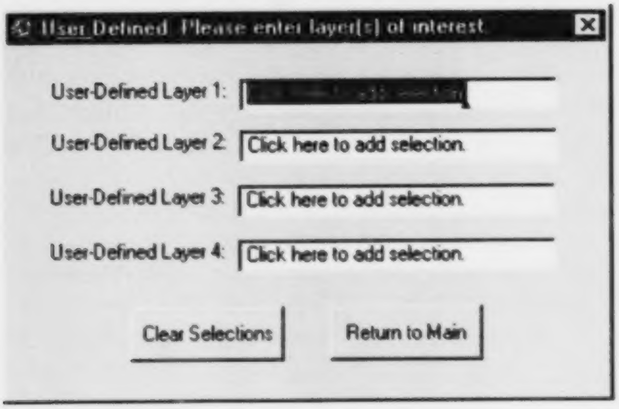
✎ ***Note**: See Appendix C for detailed information on the CN database.*

When a category button is pressed, a sub-menu appears. Select the data layer(s) of interest by checking the appropriate checkbox(es). The following figure is an example of the Geology category and the associated data layers.


Geology Please select data layer[s] of interest
☐ Suficial Geology
☐ Suficial Geology (Terrain Adjusted)
☐ Quaternary Geology
Clear Selections
Return to Main

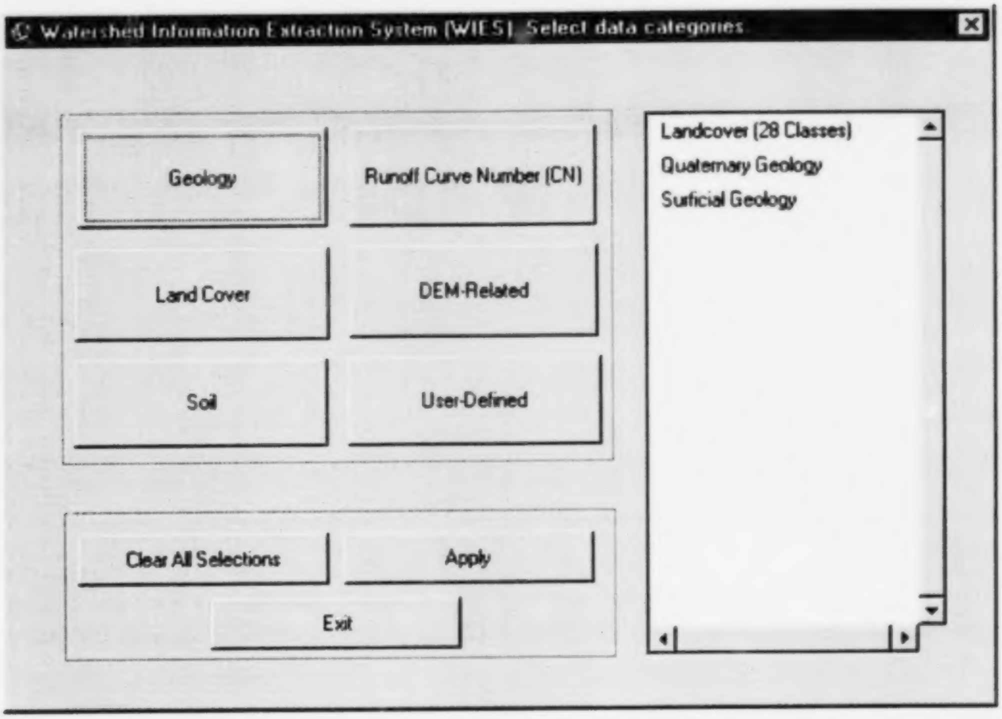
The 'User-Defined' sub-menu (seen below) is slightly different from the other sub-menus. The user has the choice of using data not supplied by OFAT. Click on a text box and specify where the data is located. The user can define up to four data layers. Presently, these data layers must be shapefiles or ArcInfo grids.

! **Warning**: *User-defined data must be in the appropriate projection. Please refer to Appendix A for projection information for each major basin.*


User Defined Please enter layer[s] of interest
User-Defined Layer 1:
User-Defined Layer 2: Click here to add selection.
User-Defined Layer 3: Click here to add selection.
User-Defined Layer 4: Click here to add selection.
Clear Selections
Return to Main

When the 'Return to Main' button on a sub-menu is pressed, the user is returned to the WIES main menu, their selection(s) appearing in the list box.

If the user needs to change their selections, they can clear the entire list box on the WIES main menu by clicking on the 'Clear All Selections' button. Another option is to return to each individual sub-menu and make changes there. To clear all the selections of each sub-menu, click 'Clear Selections' or uncheck the selection.


Watershed Information Extraction System (WIES) Select data categories
Geology
Runoff Curve Number (CN)
Land Cover
DEM-Related
Soil
User-Defined
Clear All Selections
Apply
Exit

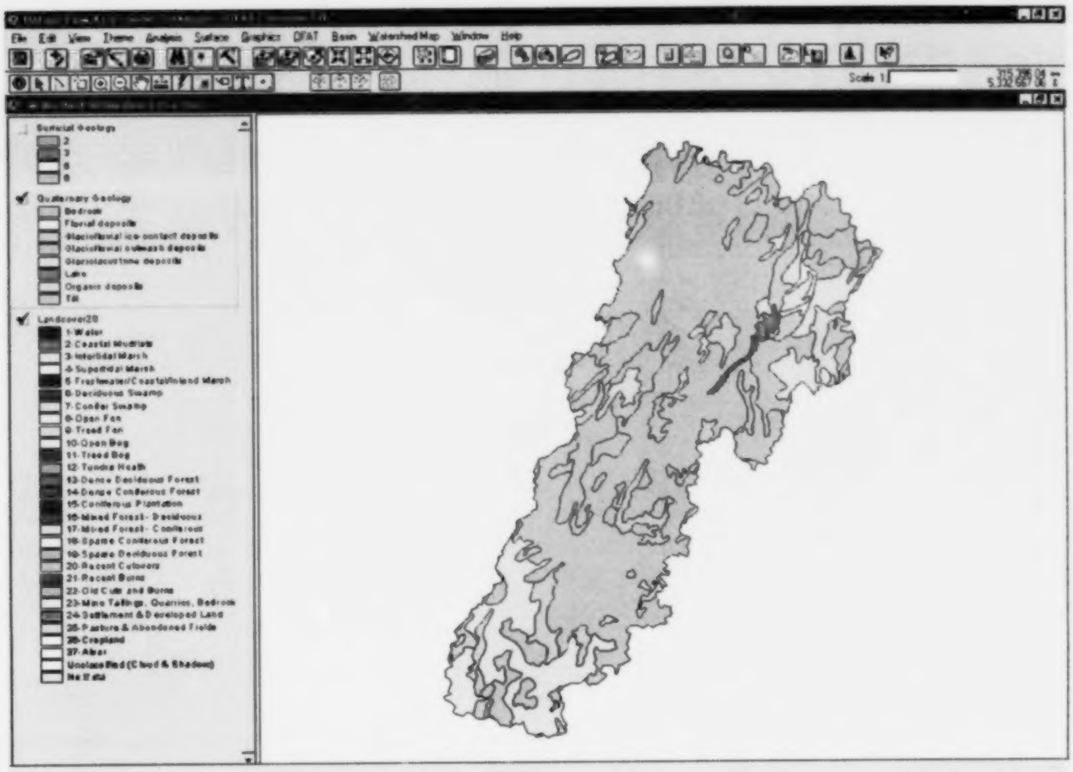
Landcover (28 Classes)
Quaternary Geology
Surficial Geology

☛ ***Note**: Grid data layers take time to process. Please be patient.*

Running WIES

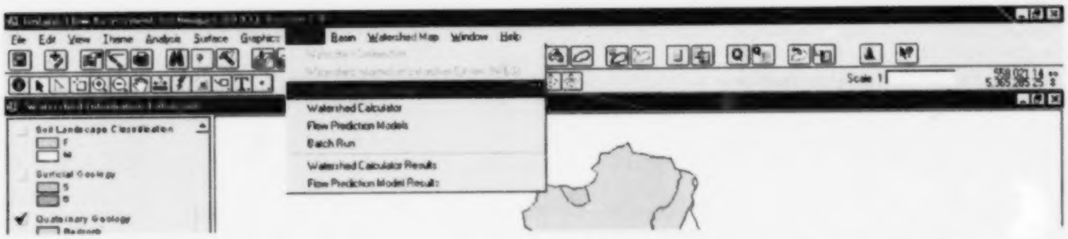
When finished making selections, click 'Apply' on the WIES main menu to extract the selected data layers to the spatial extent of the delineated watershed. The 'Watershed Information Extraction' map will appear, displaying all the extracted data layers.

At any time before the 'Apply' button is clicked, 'Exit' can be pressed to close the WIES main menu and return to the 'Selected Watershed Area' map.


File Edit View Theme Analysis Surface Graphics OFAT Basin Watershed Map Window Help
Scale 1:
Surficial Geology
2
3
5
6
Quaternary Geology
Bedrock
Fluvial deposits
Glaciofluvial ice-contact deposits
Glaciofluvial outwash deposits
Glaciolacustrine deposits
Lake
Organic deposits
Till
Landcover28
1-Water
2-Coastal Mudflats
3-Intertidal Marsh
4-Supratidal Marsh
5-Freshwater/Coastal/Inland Marsh
6-Deciduous Swamp
7-Conifer Swamp
8-Open Fen
9-Treed Fen
10-Open Bog
11-Treed Bog
12-Tundra Heath
13-Dense Deciduous Forest
14-Dense Coniferous Forest
15-Coniferous Plantation
16-Mixed Forest - Deciduous
17-Mixed Forest - Coniferous
18-Sparse Coniferous Forest
19-Sparse Deciduous Forest
20-Recent Cutovers
21-Recent Burns
22-Old Cuts and Burns
23-Mine Tailings, Quarries, Bedrock
24-Settlement & Developed Land
25-Pasture & Abandoned Fields
26-Cropland
27-Alvar
Unclassified (Cloud & Shadow)
No Data

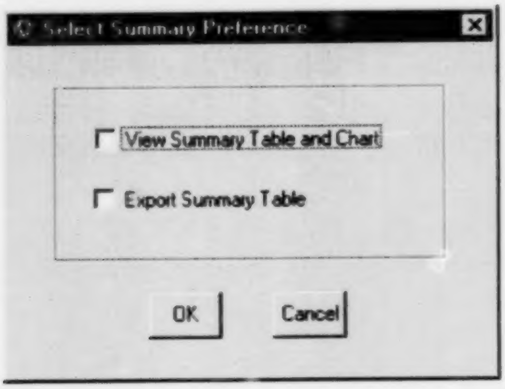
Data Summarizing Using WIES

At this stage, the results of the clipped data layers can be summarized in tables and charts. To access this function, click on the 'WIES Summary Statistics' button ▤ or select the 'WIES Summary Statistics' item in the 'OFAT' pull down menu while the 'Watershed Information Extraction' map is open.


File Edit View Theme Analysis Surface Graphics
Basin Watershed Map Window Help
Watershed Calculator
Flow Prediction Models
Batch Run
Watershed Calculator Results
Flow Prediction Model Results
Scale 1:
Soil Landscape Classification
F
M
Surficial Geology
5
6
Quaternary Geology
Bedrock

Only active themes will be summarized. To make a theme active, click on the theme's name in the Table of Contents (left side of the map). The theme will be highlighted to show that it is active. To make more than one theme active, hold down the SHIFT key while clicking on the themes to be made active.

The user now has two options for summarizing from the 'Select Summary Preference' menu:

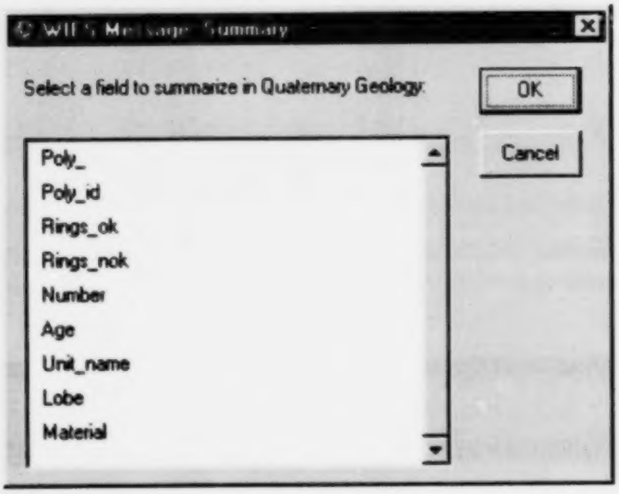


☐ View Summary Table and Chart

☐ Export Summary Table

These options can be selected by clicking in the appropriate checkbox(es). After selection, click 'OK'.

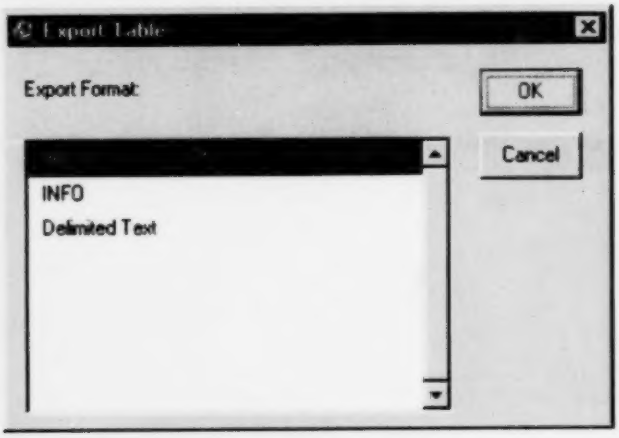
The user is required to select a field they wish to summarize for each active theme. A menu, similar to the following figure, appears with a list of fields from each of these themes. Select a field and click 'OK' for each active theme.



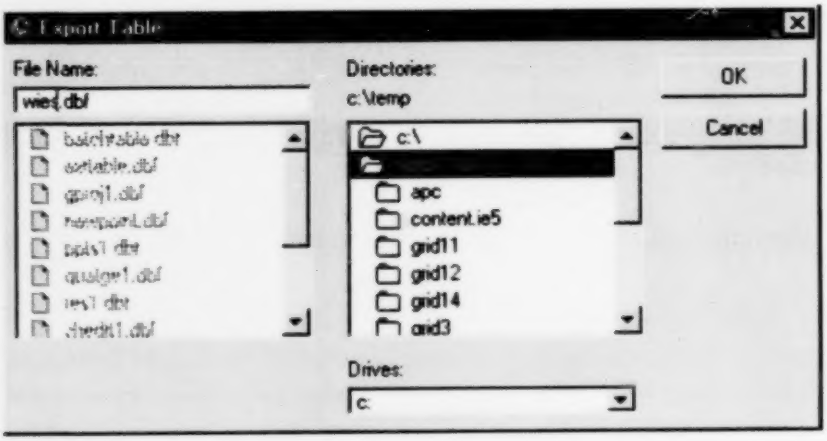
Select a field to summarize in Quaternary Geology:

- Poly_
- Poly_id
- Rings_ok
- Rings_nok
- Number
- Age
- Unit_name
- Lobe
- Material

'Export Summary Table' gives the user a choice of file types for the table to be exported in. Make a selection and click 'OK'.


Export Table
Export Format:
OK
Cancel
INFO
Delimited Text

The user will also be prompted to select a path to store the file.


File Name: wies.dbf

Directories: c:\temp

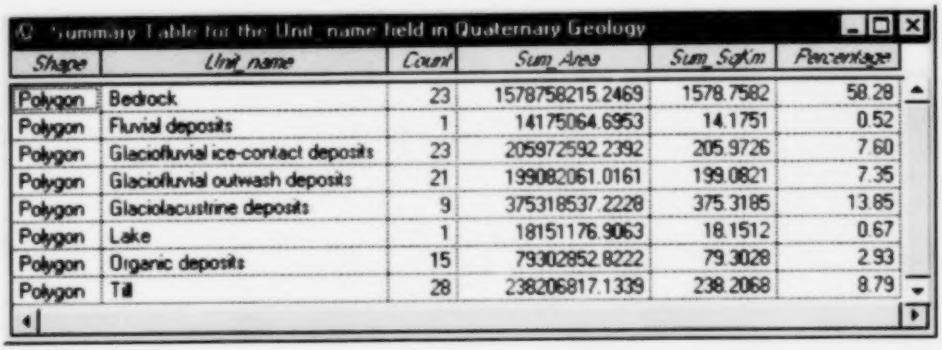
Drives: c:

Export Table
OK
Cancel
c:\
apc
content.ie5
grid11
grid12
grid14
grid3

Tables for Polygon Shapefiles

The derived summary table for a polygon theme is similar to that seen on the next page. The six fields included are as follows:

- Shape
- The selected field for summarizing (e.g., Unit_name)
- Count (number of polygons)
- Sum_Area (area in square meters)
- Sum_SqKm (area in square kilometres)
- Percentage (percentage of area)

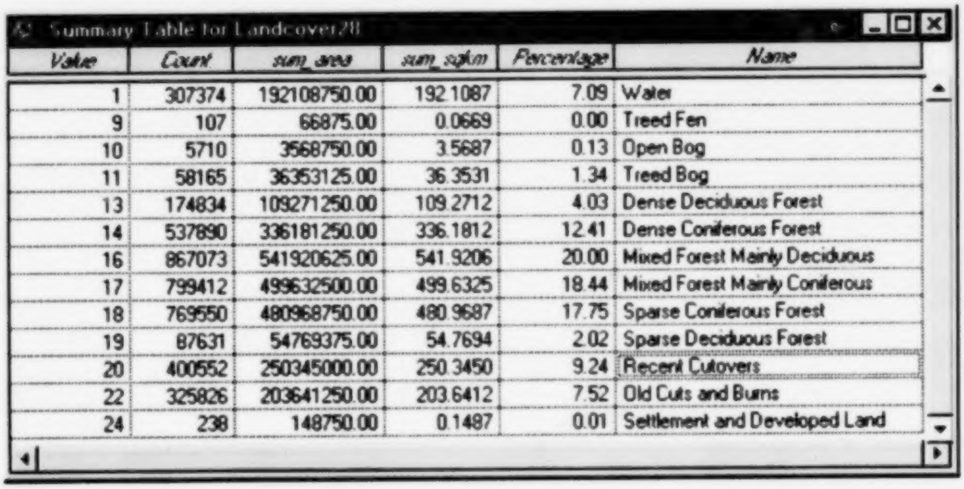


Shape	Unit_name	Count	Sum_Area	Sum_SqKm	Percentage
Polygon	Bedrock	23	1578758215.2469	1578.7582	58.28
Polygon	Fluvial deposits	1	14175064.6953	14.1751	0.52
Polygon	Glaciofluvial ice-contact deposits	23	205972592.2392	205.9726	7.60
Polygon	Glaciofluvial outwash deposits	21	199082061.0161	199.0821	7.35
Polygon	Glaciolacustrine deposits	9	375318537.2228	375.3185	13.85
Polygon	Lake	1	18151176.9063	18.1512	0.67
Polygon	Organic deposits	15	79302852.8222	79.3028	2.93
Polygon	Till	28	238206817.1339	238.2068	8.79

Tables for Grids

Summary tables for ArcInfo grids are slightly different than tables for shapefiles. 'Value' is always the field that is summarized for grids, so no field selection is needed. The fields included are as follows:

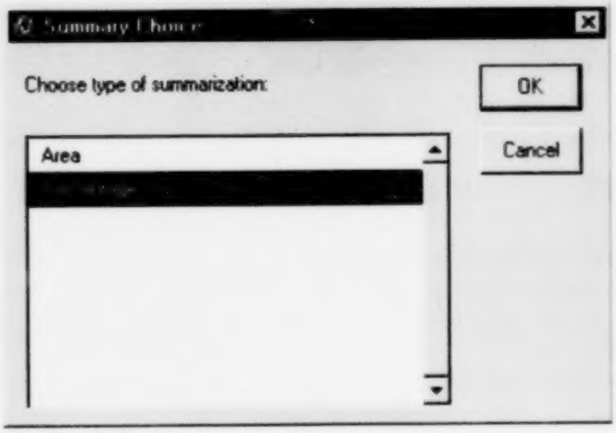
- Value (e.g., 1)
- Count (number of cells)
- Sum_Area (area in square metres)
- Sum_SqKm (area in square kilometres)
- Percentage (percentage of area)
- Name (associated with corresponding Value, if available (e.g., water))



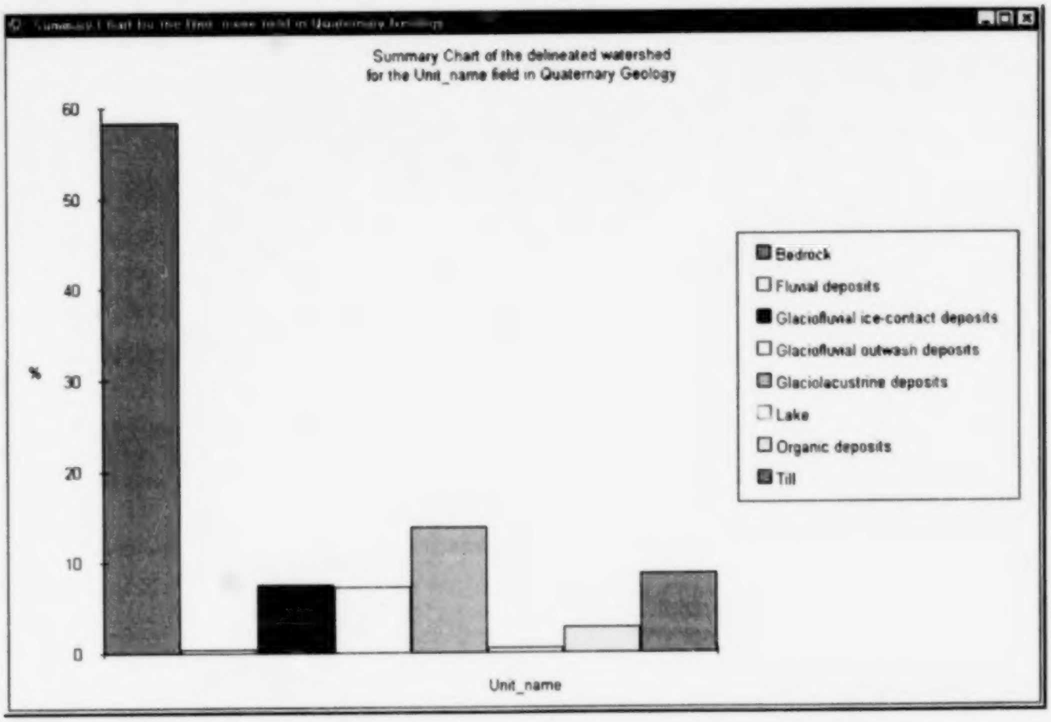
Value	Count	sum_area	sum_sqkm	Percentage	Name
1	307374	192108750.00	192.1087	7.09	Water
9	107	66875.00	0.0669	0.00	Treed Fen
10	5710	3568750.00	3.5687	0.13	Open Bog
11	58165	36353125.00	36.3531	1.34	Treed Bog
13	174834	109271250.00	109.2712	4.03	Dense Deciduous Forest
14	537890	336181250.00	336.1812	12.41	Dense Coniferous Forest
16	867073	541920625.00	541.9206	20.00	Mixed Forest Mainly Deciduous
17	799412	499632500.00	499.6325	18.44	Mixed Forest Mainly Coniferous
18	769550	480968750.00	480.9687	17.75	Sparse Coniferous Forest
19	87631	54769375.00	54.7694	2.02	Sparse Deciduous Forest
20	400552	250345000.00	250.3450	9.24	Recent Cutovers
22	325826	203641250.00	203.6412	7.52	Old Cuts and Burns
24	238	148750.00	0.1487	0.01	Settlement and Developed Land

Charts

The chart in the viewing option displays summary information for the selected field. The user can select whether they want the chart displayed with summary information in percentage or area.


Summary Choice
Choose type of summarization:
OK
Cancel
Area

Click 'OK' to proceed once the selection has been made. A chart similar to the following figure will appear.



Each theme is processed individually. The chart and table will both be displayed for one theme before the summary field for the next theme is chosen. To view all charts and tables at once, resize and rearrange the windows.

To summarize other themes that have already been extracted, go back to the 'Watershed Information Extraction' map, select different themes on the map and start the process over again. To return to the 'Watershed Information Extraction' map at any time while in the chart or table window, click on the button on the toolbar.

If new extracted layers are desired, return to the 'Selected Watershed Area' map by first clicking on the button and then clicking on the 'WIES' button to access the WIES main menu. Every time the 'WIES' button is clicked the previous selections are erased and the user is free to make new selections.

! ***Warning**: Running WIES for new data layer selections will replace the results of previous selections. To save the results, use the export summary table function.*

Batch Run

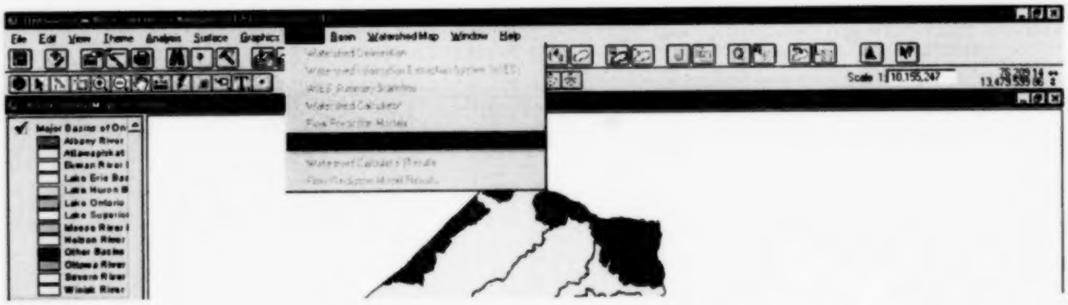
The Batch Run component allows single or multiple watersheds to be delineated without constant user interaction. Along with watershed delineation, any number of flow models and watershed parameters can be calculated in one batch run. Results are stored in an output table file.

! **Warning**: *Running OFAT with fine resolution DEMs will create large temporary files that can quickly use up computer resources. Make sure there is sufficient space on the hard drive containing the system's temporary directory (e.g., c:\temp) before running a batch containing several watershed delineations based on fine resolution DEMs.*

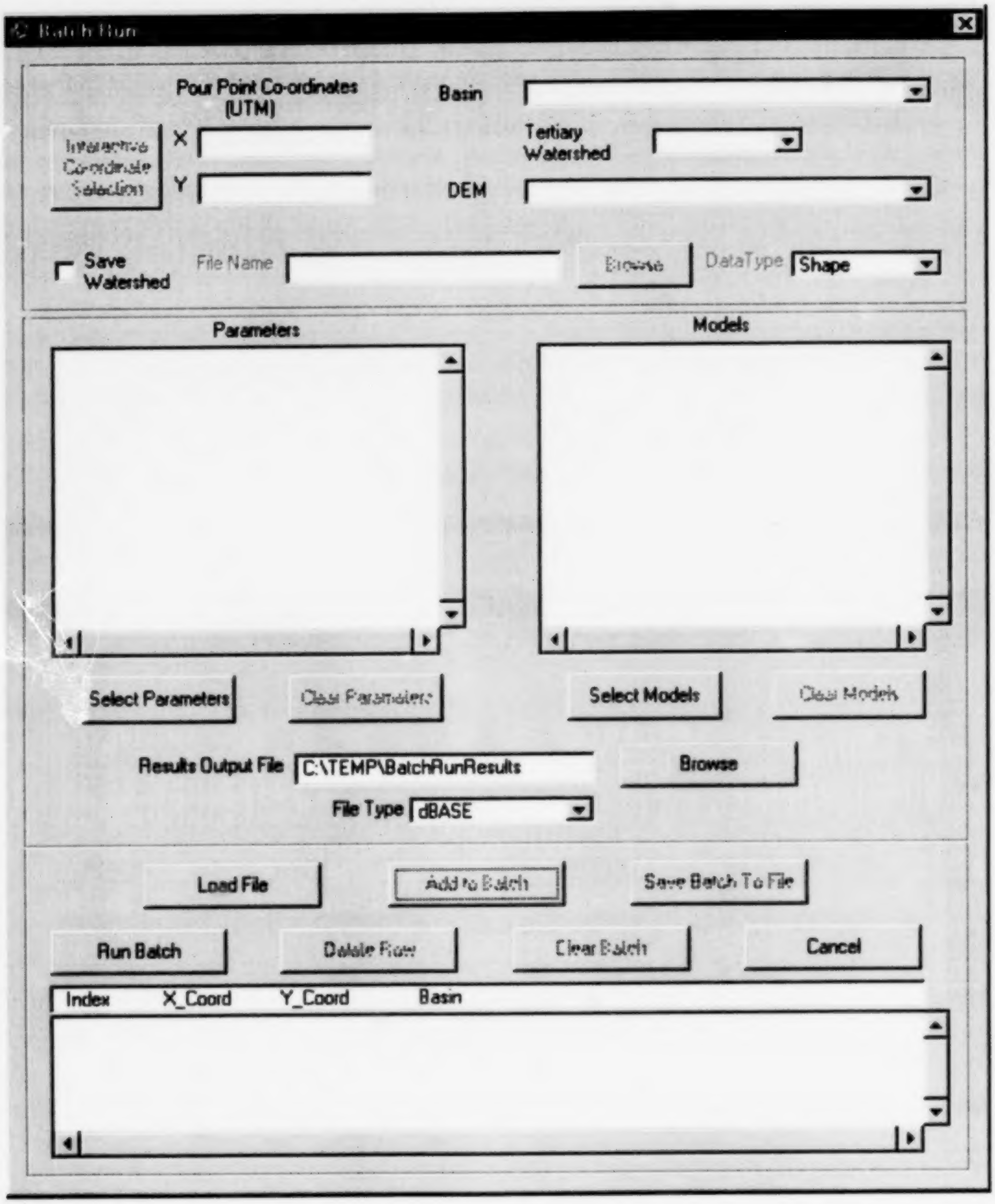
Accessing the Batch Run

There are two ways to access the batch run:

- Click the 'Batch Run' button on the toolbar
- Select the 'Batch Run' item from the 'OFAT' pull down menu


File
Edit
View
Theme
Analysis
Surface
Graphics
Basin
WatershedMap
Window
Help
Major Basins of On
Albany River
Attawapiskat
Ekwan River
Lake Erie Bas
Lake Huron B
Lake Ontario
Lake Superior
Moose River
Nelson River
Other Basins
Ottawa River
Severn River
Winisk River

A blank copy of the 'Batch Run' interface will open. All of the inputs for the batch run can be interactively completed from this interface.


Batch Run
Pour Point Co-ordinates (UTM)
Interactive Co-ordinate Selection
X
Y
Basin
Tertiary Watershed
DEM
Save Watershed
File Name
Browse
Parameters
Models
Select Parameters
Clear Parameters
Select Models
Clear Models
Browse
Load File
Add to Batch
Save Batch To File
Run Batch
Delete Row
Clear Batch
Cancel
Index
X_Coord
Y_Coord
Basin

☐ Save Watershed

DataType: Shape

Results Output File: C:\TEMP\BatchRunResults

File Type: dBASE

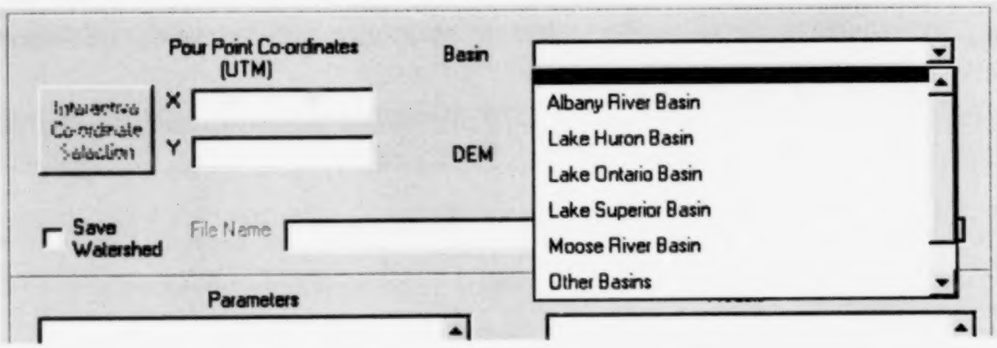
Using the Batch Run

A batch run contains a list of watersheds to be delineated and analyzed. There are several sections on the 'Batch Run' interface that must be entered before a watershed can be included in a batch run:

- Basin
- Tertiary Watershed
- DEM
- Pour Point Co-ordinates (UTM)
- Save Watershed boundary (optional)
- Parameters
- Models (optional)
- Results Output File

Basin Selection

The 'Basin' combo box contains a list of all the major basins currently installed. To choose a basin, click on the arrow to the right of the combo box to open the selection list (as shown below). Scroll through the list and click on the desired basin.


Pour Point Co-ordinates (UTM)
Interactive Co-ordinate Selection
X
Y
Basin
DEM
Save Watershed
File Name
Parameters
Albany River Basin
Lake Huron Basin
Lake Ontario Basin
Lake Superior Basin
Moose River Basin
Other Basins

The basin does not have to be selected if the desired tertiary watershed is known. Choosing a tertiary watershed before a major basin is selected will automatically select the proper basin. If a basin is selected first, only the tertiary watersheds within the basin will appear in the tertiary watershed list.

Tertiary Watershed Selection

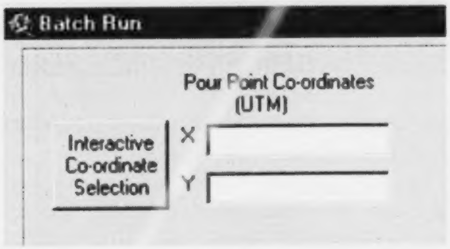
The tertiary watershed is selected in the same way as the major basin is selected. The tertiary watersheds appearing in the selection list will vary depending on the major basin that is selected. If a basin has not been selected, a complete list of available tertiary watersheds will appear for selection. A selection at this stage will automatically choose the appropriate major basin. After a basin has been selected, only the tertiary watersheds within the basin will be available within the selection list.

DEM Selection

The DEM selection combo box will become active only after a selection has been made from both the tertiary watershed and basin combo boxes. When active, the DEM selection list will contain the available DEMs for the selected tertiary watershed.

Pour Point Co-ordinate Input

If known, the X and Y co-ordinates can be entered in the corresponding text lines. If the exact UTM co-ordinates of a watershed pour point are not known, the 'Interactive Co-ordinate Selection' button can be used. The interactive button will become active after a basin, tertiary watershed and DEM have been selected.

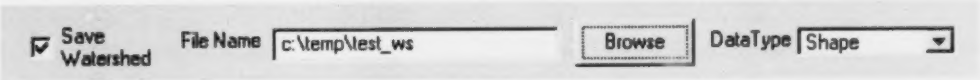

Batch Run
Pour Point Co-ordinates (UTM)
Interactive Co-ordinate Selection
X
Y

Clicking the 'Interactive Co-ordinate Selection' button will open the 'Selected Watershed Area' map and make the ◈ tool on the toolbar active (if the tool does not become active, click it). Click the pour point of interest using this tool. The 'Batch Run' interface will reopen and populate the X and Y co-ordinate lines with the co-ordinates from where the tool was clicked.

✎ ***Note**: It is recommended that when using the 'Interactive Co-ordinate Selection', the user zooms into the area of interest within the map before the pour point is selected. The 'Interactive Co-ordinate Selection' does not give a warning if a selection is made off the drainage network as when using the regular method.*

Saving the Watershed Boundary

The 'Save Watershed' checkbox allows the watershed boundary to be saved for each individual watershed. This function is optional.



☑ Save Watershed

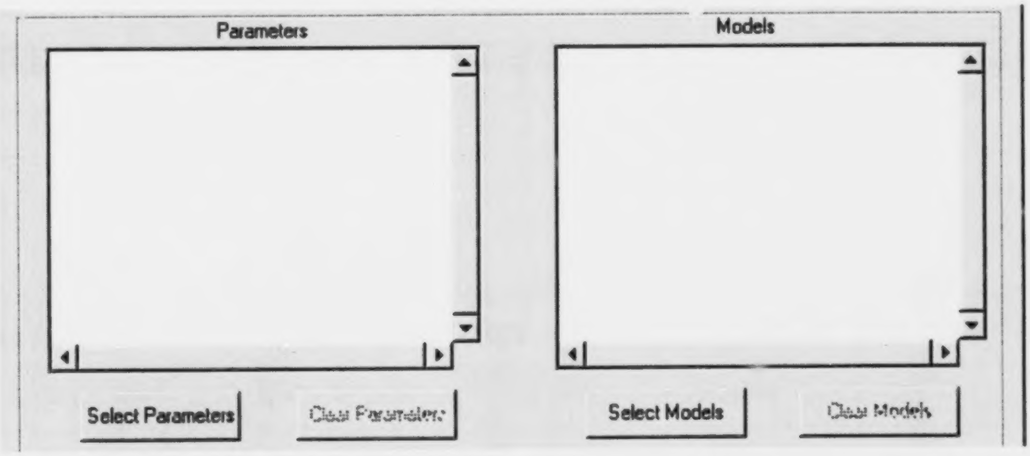
File Name c:\temp\test_ws

DataType Shape

To save a watershed boundary, make sure the 'Save Watershed' check box has been checked. This will allow access to both the 'File Name' and the 'Data Type' options. The 'File Name' text box allows the file name and path of the watershed boundary to be specified. If the path to the new file is not known, clicking 'Browse' will open the file dialog. It is recommended to change the default name. The 'Data Type' combo box contains three choices; 'Shape' which will save a shapefile, 'GRID' that will save an ArcInfo grid, or 'Both' that will save a shapefile and a grid with the specified name.

Parameter and Model Selection

Parameters and models can be selected in the batch run. Clicking on the 'Select Parameters' or 'Select Models' buttons will access the appropriate selection menus (not shown). See the 'Watershed Calculator' chapter in this manual for information on selecting parameters and the 'Using OFAT for Flow Prediction: Hydrologic Modelling' chapter for information on selecting models.

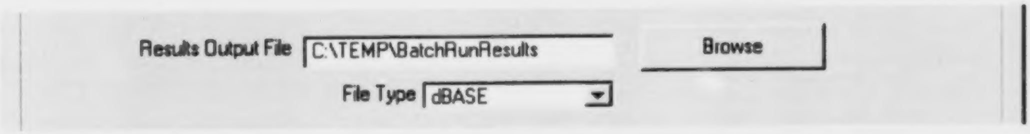


After parameter and model selections have been made, click 'Add to Batch' in the appropriate selection menu to return to the 'Batch Run' interface. The selections made will appear in the appropriate list boxes. The selected parameters and models will be overwritten with subsequent selections or can be cleared totally using the corresponding clear button. In order to run any flow models, the parameters must be selected.

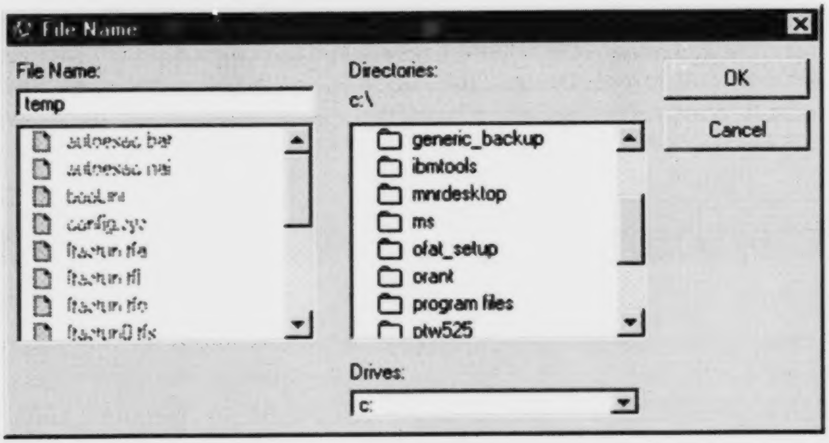
Results Output File Selection

The batch run creates a table that contains all of the results for each watershed in the batch. Three options for file type are available:

- dBase
- comma delimited text
- INFO


Results Output File C:\TEMP\BatchRunResults
File Type dBASE

The default file type for the output table is dBase (.dbf). To change the file type, use the 'File Type' combo box. To change the default file path, either type the new path into the 'Results Output File' text line, or click on the 'Browse' button to access the file dialog. The file dialog allows the user to browse through the drives and folders to find the correct location and select a file to overwrite or type in a new file name.


File Name
OK
Cancel
generic_backup
ibmtools
mnrdesktop
ms
ofat_setup
orant
program files
ptw525

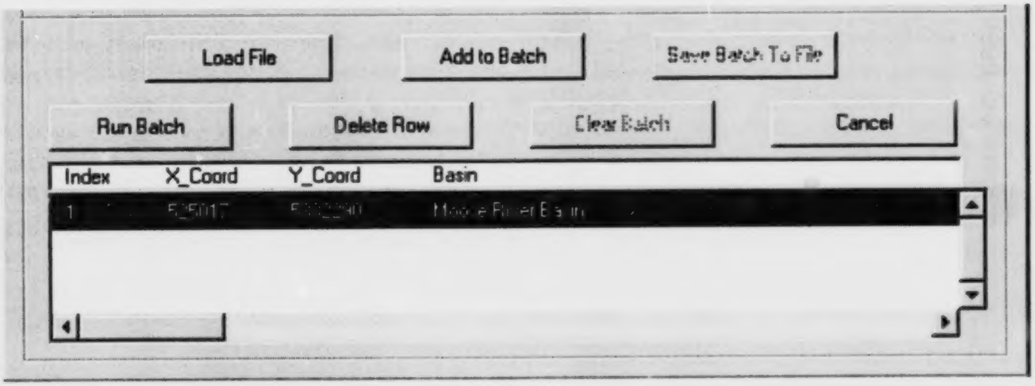
File Name: temp

Directories: c:\

Drives: c:

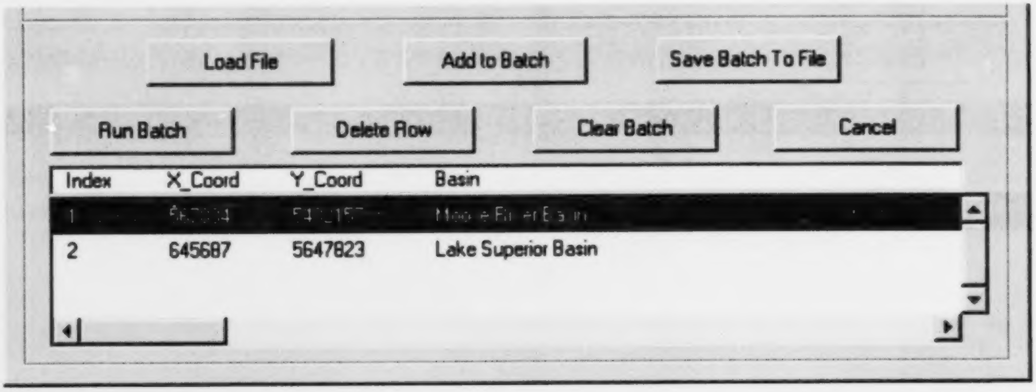
Adding to Batch

When all the required information is entered, the 'Add To Batch' button will become active. This button will move the entered information from the top of the interface to the Batch List at the bottom of the 'Batch Run' interface (shown below). When the batch run is executed, the watersheds in the list will be delineated and analyzed.


Load File
Add to Batch
Save Batch To File
Run Batch
Delete Row
Clear Batch
Cancel
Index
X_Coord
Y_Coord
Basin

Editing the Batch

To edit a record in the Batch List, select the record by clicking on it. The information pertaining to that record will appear in the appropriate location on the 'Batch Run' interface. Edit information that needs to be changed and click the 'Add to Batch' button to update the selected record.


Load File
Add to Batch
Save Batch To File
Run Batch
Delete Row
Clear Batch
Cancel

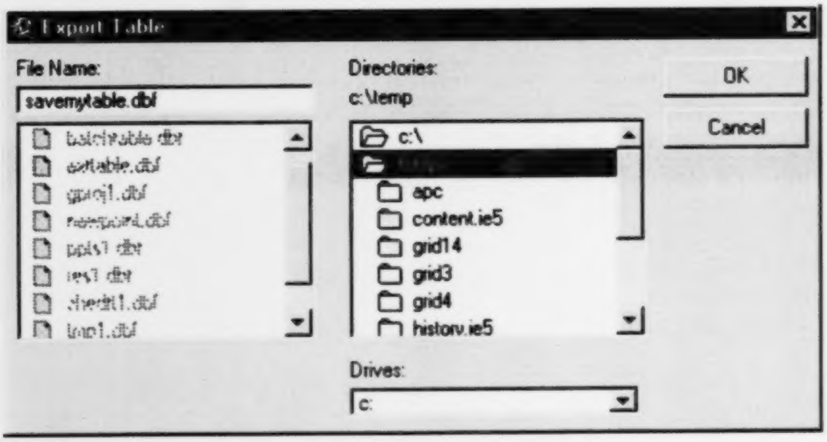
Index	X_Coord	Y_Coord	Basin
1	[illegible]	[illegible]	[illegible]
2	645687	5647823	Lake Superior Basin

If a selected record needs to be removed, clicking the 'Delete Row' button will clear the selected row. If the whole Batch List is incorrect, click 'Clear Batch'. When this button is pressed, a message box will appear asking if the Batch List is to be cleared. Pressing the default 'No' will return to the 'Batch Run' interface. Pressing 'Yes' will clear the Batch List.

! **Warning**: *If the Batch List has not been saved, there is no way to recover it once the list has been cleared or after the batch has been run.*

Saving Batch Files

To save a Batch List, click 'Save Batch to File' in the 'Batch Run' interface. This will open the 'Export Table' dialog (shown below) where the name and path of the batch file is specified.


Export Table
OK
Cancel
c:\
apc
content.ie5
grid14
grid3
grid4
historv.ie5

File Name: savemytable.dbf

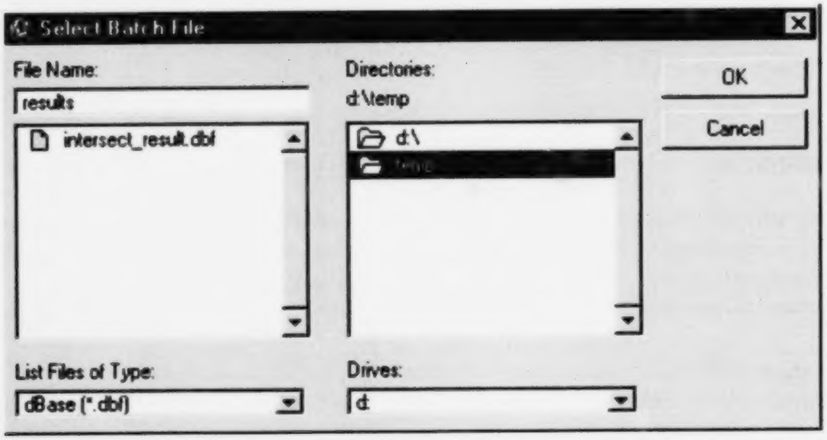
Directories: c:\temp

Drives: c:

The exported table will be saved as a .dbf (dBase) file that can be reloaded into OFAT using the 'Load File' button on the 'Batch Run' interface.

Loading a Batch File

The 'Load File' button on the 'Batch Run' interface allows loading of a previously saved batch file, or a user-generated table with batch information. Clicking the button will open the 'Select Batch File' menu. This menu allows the user to browse to a file to import into the Batch List. If the selected file cannot be imported into OFAT, a warning message will appear and the loading operation will stop. A file must be in a dBase, delimited text or INFO format to be imported into the OFAT batch process.



Select Batch File

File Name: results

Directories: d:\temp

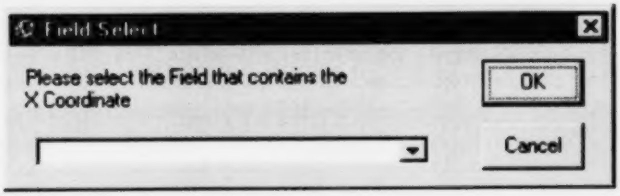
List Files of Type: dBase (*.dbf)

Drives: d:

If the selected file has been created using OFAT, it will automatically load into the Batch List. If the file has not been created with OFAT (e.g., created in MS Access), it still can be loaded using the 'Field Select' dialog that appears. The user is asked to identify the following fields within the imported table:

- X Co-ordinate
- Y Co-ordinate
- Name of the Major Basin
- Name of the Tertiary Basin
- DEM
- Decision to Save the Watershed
- File Name of the Watershed
- Data type of the Saved Watershed
- Name of the Results Output File
- Type of Results Output
- List of Parameters
- List of Models

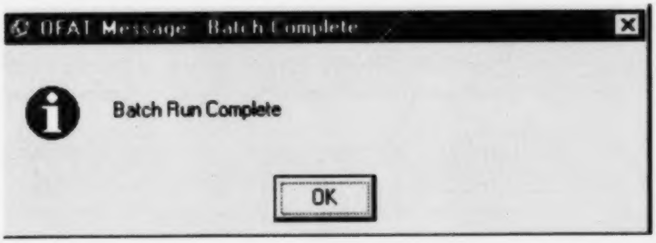
Select the field that corresponds to the item shown in the 'Field Select' dialog message. If the item shown in the message is not available from the imported file, click 'OK' with the blank field selected or click 'Cancel', to take you to the next message. When each corresponding field has been identified, the file will be added to the Batch List. If a loaded file does not contain all required information (e.g., DEM, co-ordinates), the records (watersheds) must be edited or they will not be delineated and analyzed.



Please select the Field that contains the X Coordinate

Running the Batch

When the batch has been set up, click the 'Run Batch' button. Each record in the Batch List will be executed and saved in the specified file. Any record in the Batch List that can not be executed will be skipped. When all records have been completed, the following message box will appear:



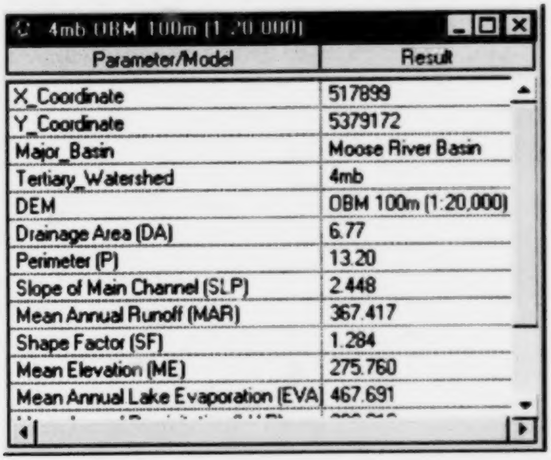
Batch Run Complete

When the batch run is completed, OFAT will return to the 'Selected Watershed Area' map.

! ***Warning**: If the Batch List has not been saved, there is no way to recover it once the list has been cleared or after the batch has been run.*

Batch Run Results

The batch run results will be added to OFAT as a table and saved to the specified file. To view the results table, click on 'Tables' in the ArcView project window and double click on the appropriate table.



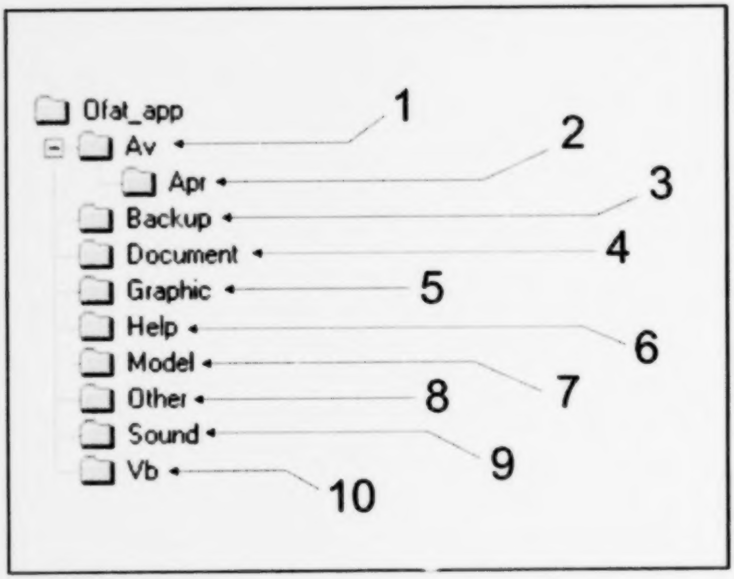
Parameter/Model	Result
X_Coordinate	517899
Y_Coordinate	5379172
Major_Basin	Moose River Basin
Tertiary_Watershed	4mb
DEM	OBM 100m (1:20,000)
Drainage Area (DA)	6.77
Perimeter (P)	13.20
Slope of Main Channel (SLP)	2.448
Mean Annual Runoff (MAR)	367.417
Shape Factor (SF)	1.284
Mean Elevation (ME)	275.760
Mean Annual Lake Evaporation (EVA)	467.691

The title of the table is the I.D. of the selected tertiary watershed combined with the selected DEM used in the batch run process (see figure above). The saved results file may also be accessed by using another program (e.g., MS Access).

OFAT Data Structure

Description of OFAT Application Folder Structure (OFAT_APP)

The OFAT software and supporting files are kept within the 'OFAT_APP' folder on the drive OFAT was installed. Several sub-folders used to organize components of the application are also contained in this folder. This folder can also be found on the OFAT Setup CD.



The following describes the file structure for 'OFAT_APP' as illustrated in the diagram above:

1. Av
   - Contains the Apr folder
   - May be used in future expansion of OFAT

2. Apr
   - Contains *Ofat.apr* project file (*Ofat.apr* is the OFAT software that contains all scripts and customizations within ArcView)
   - Contains *Ofatdata.txt* text file (used to define the 'OFATDATA' system variable that points to the 'OFAT_DAT' folder)

3. Backup
   - May be used in future expansion of OFAT

4. Document
   - Contains *OFAT User's Manual.pdf* (Adobe Acrobat Reader format of the OFAT User's Manual)

5. Graphic
   - Contains all graphics used in the application

6. Help
   - Contains the Online Help file *OFAT.hlp*

7. Model
   - *Models.txt* is a text file which the application uses to display available flow models
   - *Wshedtopology.txt* is a text file which lists the topology of tertiary watersheds (i.e., upstream-downstream relationship)

8. Other
   - Stores other supporting files including the Adobe Acrobat Reader 4.0 installation software (filename: *AR40ENG.exe*)

9. Sound
   - Contains sound files used in the application

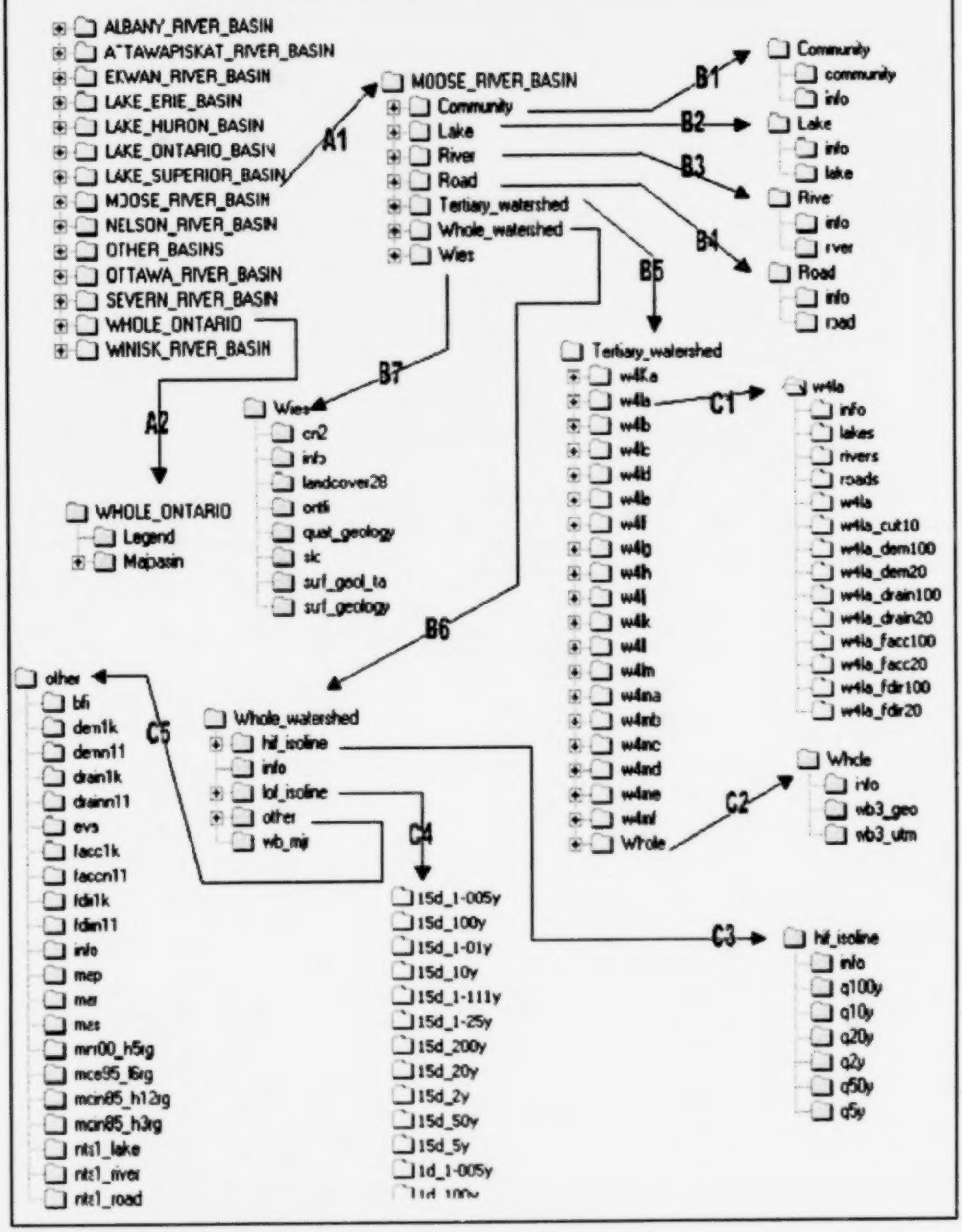
10. Vb
    - May be used in future expansion of OFAT

Description of OFAT Database Folder Structure (OFAT_DAT)

The OFAT database and supporting files are kept within the 'OFAT_DAT' folder on the drive OFAT was installed. To accommodate the large number and size of data files required for OFAT, the database was divided into a series of folders. The primary folder structure begins with the major basin names of Ontario (e.g., 'Moose_River_Basin'), plus two folders titled 'Other_Basins' and 'Whole_Ontario'. The number of major basin folders depends on the data that has been installed by the user. The data in the 'Whole_Ontario' folder is installed automatically during the initial set up in order to run OFAT properly. 'Other_Basins' contains several individual tertiary watersheds that flow directly into James Bay and Hudson Bay. This basin is treated in the same manner as the rest of the major basins.

✎ ***Note**: Information on data formatting can be found throughout this chapter and in the 'Metadata' section of the OFAT Online Help.*

✎ ***Note**: Future versions of OFAT will enhance data importing capabilities. Currently, only the WIES component can be used with imported watershed data. Other components of OFAT require specific data formatting and folder structure.*



OFAT DATABASE FOLDER STRUCTURE

ALBANY_RIVER_BASIN
A"TAWAPISKAT_RIVER_BASIN
EKWAN_RIVER_BASIN
LAKE_ERIE_BASIN
LAKE_HURON_BASIN
LAKE_ONTARIO_BASIN
LAKE_SUPERIOR_BASIN
MOOSE_RIVER_BASIN
NELSON_RIVER_BASIN
OTHER_BASINS
OTTAWA_RIVER_BASIN
SEVERN_RIVER_BASIN
WHOLE_ONTARIO
WINISK_RIVER_BASIN
A1
MOOSE_RIVER_BASIN
Community
Lake
River
Road
Tertiary_watershed
Whole_watershed
Wies
B1
Community
community
info
B2
Lake
info
lake
B3
Rive
info
river
B4
Road
info
road
B5
A2
WHOLE_ONTARIO
Legend
Mapasin
B7
Wies
cn2
info
landcover28
ortfi
quat_geology
slc
surf_geol_ta
surf_geology
Tertiary_watershed
w4Ka
w4la
w4lb
w4lc
w4ld
w4le
w4lf
w4lg
w4lh
w4lj
w4lk
w4ll
w4lm
w4ma
w4mb
w4mc
w4md
w4me
w4mf
Whole
C1
w4la
info
lakes
rivers
roads
w4la
w4la_cut10
w4la_dem100
w4la_dem20
w4la_drain100
w4la_drain20
w4la_facc100
w4la_facc20
w4la_fdir100
w4la_fdir20
C2
Whole
info
wb3_geo
wb3_utm
B6
other
bfi
dem1k
demn11
drain1k
drainn11
evs
facc1k
faccn11
fdir1k
fdirn11
info
mep
mer
mes
mn00_h5rg
mce95_l6rg
mcin85_h12rg
mcin85_h3rg
nts1_lake
nts1_river
nts1_road
C5
Whole_watershed
hif_isoline
info
lof_isoline
other
wb_mji
C4
15d_1-005y
15d_100y
15d_1-01y
15d_10y
15d_1-111y
15d_1-25y
15d_200y
15d_20y
15d_2y
15d_50y
15d_5y
1d_1-005y
C3
hif_isoline
info
q100y
q10y
q20y
q2y
q50y
q5y

The following describes data structure for 'OFAT_DAT' folder as illustrated in the preceding diagram. Data pertaining to the Moose River Basin is used as an example:

A1 'MOOSE_RIVER_BASIN'

- This is an example of a major basin folder showing its sub-folders.
- All the OFAT data pertaining to a major basin is stored in each of these folders named by corresponding major basin names.

A2 'WHOLE_ONTARIO'

- The contents of the 'Whole_Ontario' folder includes the 'Legend' and 'MajBasin' sub-folders.
- The 'Legend' sub-folder contains legend files that are used for legend text and graphics.
- The 'MajBasin' folder contains the 'MajBasin' coverage that allows the user to select a major basin.

B1 'Community'

- The 'Community' sub-folder contains a coverage of communities within a particular major basin.
- The 'Community' coverage is used for visual representation in the tertiary watershed index map.

B2 'Lake'

- The 'Lake' sub-folder contains a coverage of lakes and wetlands within a particular major basin.
- The 'Lake' coverage is used for visual representation in the tertiary watershed index map.

B3 'River'

- The 'River' sub-folder contains a coverage of the rivers within a particular major basin.
- The 'River' coverage is used for the visual representation in the tertiary watershed index map.

B4 'Road'

- The 'Road' sub-folder contains a coverage of the roads within a particular major basin.
- The 'Road' coverage is used for the visual representation in the tertiary watershed index map

B5 'Tertiary_watershed'

- The 'Tertiary_watershed' sub-folder contains all the sub-folders of the tertiary watersheds within a particular major basin (e.g., sub-folder 'w4la' is for tertiary watershed 4LA) and the 'Whole' folder.
- All available data for a particular tertiary watershed is stored in each corresponding sub-folder.
- The 'Whole' sub-folder contains coverages of tertiary watersheds within a major basin.

B6 'Whole_watershed'

- The 'Whole_watershed' sub-folder contains several sub-folders that store 1km resolution grids pertaining to flow models, climate, and DEMs.
- All the data under this sub-folder covers the full spatial extent of a major basin.
- 'Wb_mjr' is the coverage for the boundary of the major basin.

B7 'Wies'

- The 'Wies' sub-folder contains all coverage and grid data needed in WIES. This data covers the full spatial extent of a major basin.
- 'CN2' is a 25m resolution grid used for extracting runoff curve numbers under average AMC (CN_{II}). CN_{II} is used to calculate CN_I and CN_{III}. Refer to Appendix C for more details about runoff curve numbers.
- 'Landcover28' is a 25m resolution grid used for extracting land cover classifications.
- 'Ontli' coverage is used for extracting Ontario Land Inventory (OLI) data.
- 'Quat_geology' coverage is used for extracting quaternary geology data.
- 'SLC' coverage is used for extracting soil landscape data.
- 'Surf_geol_ta' coverage is used for extracting terrain adjusted surficial geology data.
- 'Surf_geology' coverage is used for extracting surficial geology data.

C1 'w4la'

4LA is an example of a tertiary watershed sub-folder containing selected NRVIS base layers, the watershed boundary, and all NRVIS-based 20m and 100m resolution grid data for a particular tertiary watershed.

- 'Lakes' coverage is used for visual representation in the 'Selected Watershed Area' map.
- 'Rivers' coverage is used for visual representation in the 'Selected Watershed Area' map.
- 'Roads' coverage is used for visual representation in the 'Selected Watershed Area' map.
- 'w4la' is a coverage used for displaying the boundary of tertiary watershed in the 'Selected Watershed Area' map.
- 'w4la_cut10' is a coverage of a tertiary watershed boundary with a 10km buffer that is used to clip DEM-related data.
- 'w4la_dem100' is a NRVIS-based 100m resolution DEM, generated by the OFAT project, used for watershed delineation and analysis.
- 'w4la_dem20' is a NRVIS-based 20m resolution DEM used for watershed delineation and analysis (MNR, 2002).
- 'w4la_drain100' is a NRVIS-based 100m resolution drainage line grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'w4la_drain20' is a NRVIS-based 20m resolution drainage line grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'w4la_facc100' is a NRVIS-based 100m resolution flow accumulation grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'w4la_facc20' is a NRVIS-based 20m resolution flow accumulation grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'w4la_fdir100' is a NRVIS-based 100m resolution flow direction grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'w4la_fdir20' is a NRVIS-based 20m resolution flow direction grid, generated by the OFAT project, used for watershed delineation and analysis.

C2 'Whole'

- 'Whole' is a sub-folder of tertiary watersheds containing the polygon coverage of tertiary watersheds within the major basin.
- 'wb3_geo' coverage is used to visually identify a tertiary watershed projected in Geographic (latitude-longitude).
- 'wb3_utm' coverage is used to visually identify a tertiary watershed projected in UTM.

C3 'hif_isoline'

- 'hif_isoline' is a sub-folder containing all grid data generated from hydrometric station data pertaining to high flow models for a major basin.
- 'q100y' is a 1km resolution grid representing unit-high flow in a 100-year return period and is used by the Isoline Model (MNR, 2000).
- 'q10y' is a 1km resolution grid representing unit-high flow in a 10-year return period and is used by the Isoline Model (MNR, 2000).
- 'q20y' is a 1km resolution grid representing unit-high flow in a 20-year return period and is used by the Isoline Model (MNR, 2000).
- 'q2y' is a 1km resolution grid representing unit-high flow in a 2-year return period and is used by the Isoline Model (MNR, 2000).
- 'q50y' is a 1km resolution grid representing unit-high flow in a 50-year return period and is used by the Isoline Model (MNR, 2000).
- 'q5y' is a 1km resolution grid representing unit-high flow in a 5-year return period and is used by the Isoline Model (MNR, 2000).

C4 'lof_isoline'

- 'Lof_isoline' is a sub-folder containing all grid data generated from hydrometric station data pertaining to low flow models for a major basin.
- '15d_1-005y' is a 1km resolution grid representing 15-day average unit-low flow in a 1.005-year return period and is used by the Isoline Model (MOEE, 1995).
- '15d_100y' is a 1km resolution grid representing 15-day average unit-low flow in a 100-year return period and is used by the Isoline Model (MOEE, 1995).
- 'mo_7q20-jan' is a 1km resolution grid representing 7-day average unit-low flow in a 20-year return period for the month of January and is used by the Isoline Model (MOEE, 1995).

✎ ***Note**: There are many variations of the above, however, there are too many to list.*

C5 'Other'

- 'Other' is a sub-folder containing additional grid data and selected NTS 1:250,000 base layers.
- 'bfi' is a 1km resolution grid used by the Watershed Calculator for extracting the base flow index.
- 'dem1k' is a NRVIS-based 1km resolution DEM, generated by the OFAT project, used for watershed delineation and analysis.
- 'demn11' is a NTS-based (1:250,000) 1km resolution DEM, used for watershed delineation and analysis.

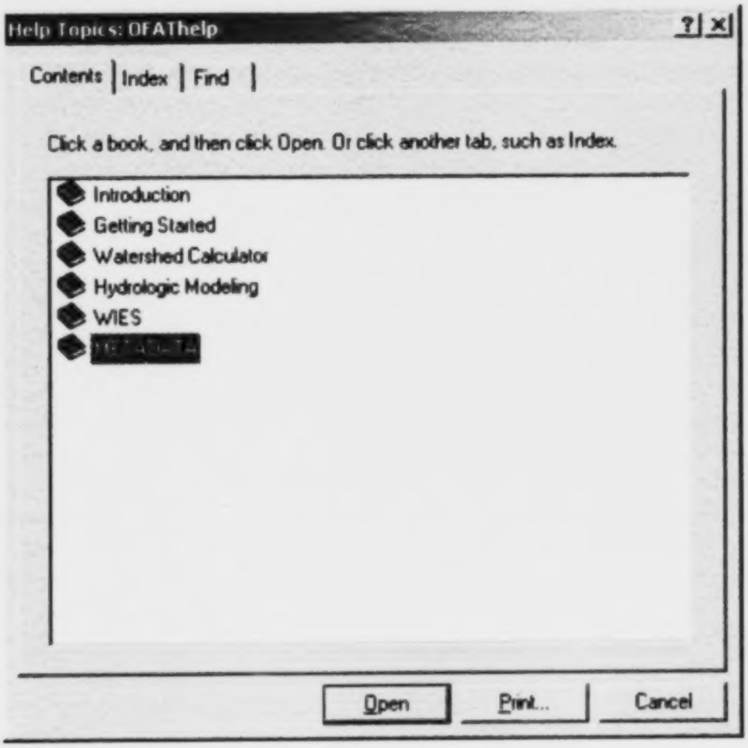
- 'drain1k' is a NRVIS-based 1km resolution drainage line grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'drainn11' is a NTS-based (1:250,000) 1km resolution drainage line grid, used for watershed delineation and analysis.
- 'eva' is a 1km resolution grid used by the Watershed Calculator for extracting average mean annual lake evaporation values.
- 'facc1k' is a NRVIS-based 1km resolution flow accumulation grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'faccn11' is a NTS-based (1:250,000) 1km resolution flow accumulation grid, used for watershed delineation and analysis.
- 'fdir1k' is a NRVIS-based 1km resolution flow direction grid, generated by the OFAT project, used for watershed delineation and analysis.
- 'fdirn11' is a NTS-based (1:250,000) 1km resolution flow direction grid, used for watershed delineation and analysis.
- 'map' is a 1km resolution grid used by the Watershed Calculator for extracting mean annual precipitation values.
- 'mar' is a 1km resolution grid used by the Watershed Calculator for extracting mean annual runoff values.
- 'mas' is a 1km resolution grid used by the Watershed Calculator for extracting mean annual snowfall values.
- 'mnr00_h5rg' is a 1km resolution grid representing five high flow regions and is used by high flow models (MNR, 2000).
- 'moe95_l6rg' is a 1km resolution grid representing six low flow regions and is used by low flow models (MOEE, 1995).
- 'moin85_h12rg' is a 1km resolution grid representing 12 high flow regions and is used by high flow models (Moin and Shaw, 1985).
- 'moin85_h3rg' is a 1km resolution grid representing three high flow regions and is used by high flow models (Moin and Shaw, 1985).
- 'nts1_lake' is a lake coverage used for visual representation in the 'Selected Watershed Area' map when the 1km resolution DEM is used.
- 'nts1_river' is a coverage used for visual representation in the 'Selected Watershed Area' map when the 1km resolution DEM is used.
- 'nts1_road' is a coverage used for visual representation in the 'Selected Watershed Area' map when the 1km resolution DEM is used.

OFAT Metadata

Online Help for Metadata

In order to keep track of the large database associated with the OFAT application, a 'Metadata' section has been developed as part of the OFAT Online Help. Before using this section of the Online Help, take a moment to understand how it is constructed and what information it can provide. Metadata stores information about data layers such as projections, scale/resolutions, source, and how it was created or where it was acquired.

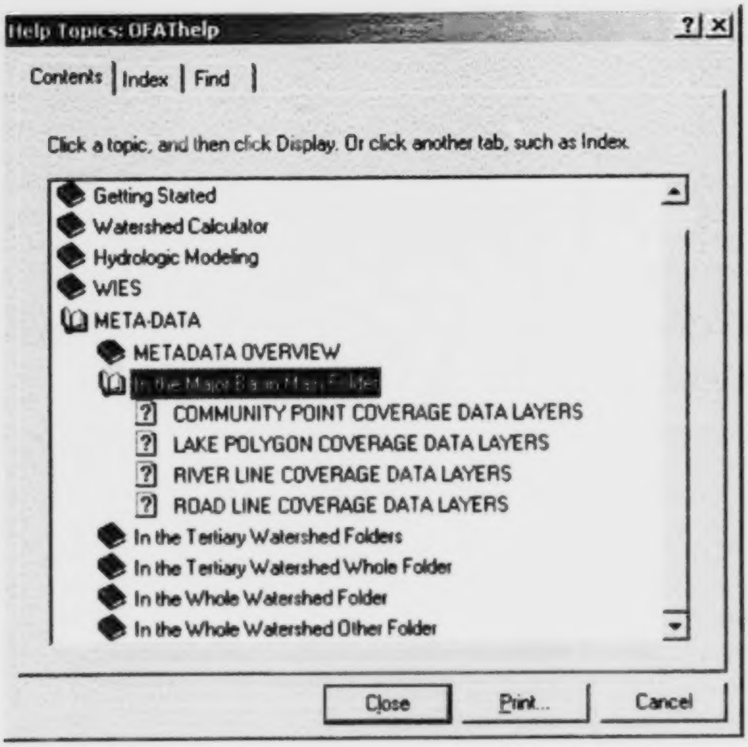
✎ ***Note**: To access the Online Help, please refer to the 'Where to Go for More Help' section of this manual.*



Click a book, and then click Open. Or click another tab, such as Index.

Help Topics: OFAThelp
?
×
Contents
Index
Find
Introduction
Getting Started
Watershed Calculator
Hydrologic Modeling
WIES
Open
Print...
Cancel

Each booklet of metadata help is organized in the same sequence as the sub-folders found under the 'OFAT_DAT' folder. A topic provides specific information for a data layer (see the following figure). Key words have been highlighted and can be clicked to provide a more detailed description.



Click a topic, and then click Display. Or click another tab, such as Index.

- Getting Started
- Watershed Calculator
- Hydrologic Modeling
- WIES
- META-DATA
  - METADATA OVERVIEW
  - In the Major Basin Main Folder
    - COMMUNITY POINT COVERAGE DATA LAYERS
    - LAKE POLYGON COVERAGE DATA LAYERS
    - RIVER LINE COVERAGE DATA LAYERS
    - ROAD LINE COVERAGE DATA LAYERS
  - In the Tertiary Watershed Folders
  - In the Tertiary Watershed Whole Folder
  - In the Whole Watershed Folder
  - In the Whole Watershed Other Folder

Each topic includes the following:

- Layer Specifications – provides information on projection, datum, spheroid, units, resolution, and zone
- How Was the Data Created – provides information on source data (e.g., scale) and data preparation
- A Sample Graphic – provides a visual representation of the layer; not all data layers will be visible while using OFAT

Frequently Asked Questions (FAQ)

This chapter will help users find answers to questions they may have about OFAT software and databases.

1. **Can I share OFAT data with others or use OFAT data for other purposes?**

   A The OFAT software and all related databases are copyright protected. Please refer to the 'Trademarks and Copyright' section in the beginning of this user's manual.

2. **Can I run OFAT with the ArcView 8.x or ArcGIS 8.x working environment?**

   A No, OFAT cannot be run with ArcView 8.x or ArcGIS 8.x working environment. OFAT was designed to run with ArcView 3.2a.

3. **What should I do if I want to install a database for a basin that has never been loaded, or update databases for basins that have been previously loaded, after OFAT is installed?**

   A Re-install OFAT using the OFAT CDs. When prompted to select an installation option, choose the 'Install OFAT databases only' option and proceed to select the desired basins and databases to install or update.

4. **Why are some of the options on OFAT interfaces (e.g., DEM selection menu) dimmed out?**

   A When a database is not available, the corresponding options are dimmed out on the interfaces. In order to have the options become available for selection, appropriate databases must be installed by using the OFAT CDs. Also, certain options in dialogs are dimmed out and used as placeholders. They will be available for a future version of OFAT.

5. **Why are the buttons on the OFAT toolbar dimmed out?**

   A The buttons and tools on the OFAT toolbar are dimmed out when the necessary tasks preceding the button/tool functions have not been performed yet. Make sure all the preceding steps have been completed to make the button/tool become available.

6. **How many watersheds can I perform OFAT functions on at once?**

   A By following the standard OFAT process, functions of OFAT major components (including Watershed Delineation, Watershed Calculator, Flow Prediction Models, and WIES) can be performed on only one watershed, at a time. However, the Batch Run can be used to perform OFAT functions on multiple watersheds. The selected watersheds can be selected from different tertiary watersheds and different major basins. Please note that the more watersheds to be delineated and analyzed, the longer the processing time it will take.

7. **Can I use my own dataset (e.g., DEM) in OFAT?**

   A Currently, WIES is the only component in OFAT that allows the users to use their own data. Users can not use their own dataset with other components in OFAT yet.

8. **How do I use OFAT outputs to support other water resource-related applications?**

   A OFAT can export the results of delineated watershed boundary, WIES summary statistics, watershed parameters, and flow modeling in different formats. These exported results (e.g., shapefile, delimited text file, .dbf file) can then be imported into other water resource-related applications for other purposes.

9. **How can I save the project? Can I save and start where I left off during a process if I run out of time?**

   A The OFAT project file (i.e., *OFAT.apr*) can not be saved. However, results generated by OFAT (e.g., delineated watershed, calculated watershed parameters, summarized watershed information, flow information, batch run) can be exported into various formats. Also, when using the Batch Run, a batch file can be saved and then loaded back into OFAT.

10. **When I click on a major basin to select it, why do I get a message stating "The basin is not available"?**

    A The major basin that you are clicking on should be coloured grey. This means the database for that basin has not been installed. To add the databases for that basin, please install using the OFAT CDs.

11. **What resolution of DEM should I use to delineate/analyze the watershed of my interest?**

    A The choice of DEM depends on your application and the accuracy you would like to achieve. Generally, a DEM of finer resolution would provide you with results at higher accuracy but will take longer to delineate/analyze the watershed.

12. **Why does OFAT take so long to delineate a watershed?**

    A Please check if your computer hardware meets the minimum system requirements of OFAT. Also, please note that the finer the DEM cell resolution you choose, the longer time OFAT takes to delineate a watershed. For example, if you are working with a DEM of 20m or finer resolution, please be patient.

13. **Why does the tertiary watershed boundary not match the boundary delineated by using the selected DEM?**

    A The original tertiary watershed boundaries were manually traced and digitized based on 1:600,000 provincial paper maps, producing general boundary outlines. The boundaries delineated in OFAT are much more accurate since the DEMs were generated based on elevation data of a larger scale (i.e., 1:10,000 for southern and 1:20,000 for northern Ontario). In the future, new tertiary watershed boundaries will be generated using the most up-to-date DEMs so they will match the watershed boundaries delineated by OFAT.

14. What should I do if the watershed of my interest is larger than a whole tertiary watershed?

A If the watershed to be delineated is larger than one whole tertiary watershed, a DEM with a cell resolution of 100m or greater must be used. Make sure the specified pour point is on the main channel of the most downstream tertiary watershed. Algorithms have been built into OFAT to automatically merge related upstream tertiary watersheds. Please note that merging tertiary watersheds will take time.

15. Can I import an existing watershed boundary delineated from other methods?

A Yes, an existing watershed boundary in ArcView shapefile or ArcInfo grid format can be imported into OFAT. However, at this time, the imported watershed can only be used with the WIES component. The imported watershed boundary can not be used with the Watershed Calculator and Flow Prediction Models components, which only use watersheds directly delineated by OFAT.

16. What if I only need a watershed boundary but no watershed parameters or flow information?

A OFAT will delineate a watershed based on the user-specified pour point. The delineated watershed can be exported as a shapefile or ArcInfo grid. The exported watershed boundary can then be used for different purposes (e.g., importing into other water resource-related applications). It is not necessary to run the Watershed Calculator or Flow Prediction Models components if the watershed parameters or flow information are not needed.

17. What is the difference between optional and required parameters in the Watershed Calculator?

A The required parameters are needed to run the flow models currently included in OFAT. The optional parameters are not currently needed for the flow models in OFAT but can provide extra information about a watershed. The user is given the choice of calculating the optional parameters because the calculations for some parameters are very time consuming such as maximum flow distance (MFD).

18. How do I know which model works best for a specific geographic area?

A Each regional hydrological model in OFAT has its own limitations. It is highly recommended that users refer to the original model document, or if necessary a water professional, before using generated flow values for any decision making purpose.

19. How many flow prediction models can I run at once?

A You can run as many flow models as you want at the same time. Not only can any number of models be selected for each model category (e.g., low flow) but also models from multiple categories can be selected and run consecutively.

20. Why does OFAT show negative values for some low flow models?

A Negative values do not reflect an incorrect algorithm in OFAT but simply a misuse of the model for the delineated watershed. For example, using the low flow models, such as the Regression Method (MOEE, 1995), for a very small watershed may result in negative values. The low flow models chosen by the user may not be suitable for the delineated watershed (i.e., the calculated watershed parameters, such as drainage area, are outside the limits originally used to develop the models). Please consult a water professional and refer to the original model documents for more information about the use of different flow models.

21. Where can I find a model that will give me Q_{25} (i.e., flood flow in a 25-year return period)?

A Currently, the only model in OFAT that can calculate Q_{25} is the Index Flood, Regional Flood Frequency Curve Method (MNR, 2000).

22. Can OFAT produce hydrographs (the graph showing time versus discharge)?

A Although OFAT can generate flow information for a watershed such as floods (Q_{25}, Q_{100}, etc.), low flows ($7Q_2$, $7Q_{20}$), etc., it cannot derive a hydrograph for the watershed.

23. Can I use WIES in a batch run for multiple watersheds?

A The current batch run in OFAT cannot be used with WIES to summarize spatial databases for multiple watersheds. That means that the WIES component can only be used for a single watershed at a time. There are plans to include this feature in a future version of OFAT.

24. Can I execute a batch run for watersheds in different tertiary watersheds of different major basins?

A Yes, a batch run can perform OFAT functions for watersheds in different tertiary watersheds of different major basins. Also, different resolution DEMs can be used for delineating watersheds selected in the batch run.

25. What should I do when I get an error message upon exiting OFAT?

A When exiting, OFAT will delete temporary files that have been created during OFAT sessions. If this procedure can not be completed properly, an error message will occur. In this case, to exit OFAT, click 'OK' in the error message. OFAT requires large temporary hard disk space to run the software efficiently and smoothly. Although OFAT has been designed to automatically delete unnecessary temporary files on-the-fly, sometimes the temporary files created by OFAT cannot be deleted. Therefore, it is strongly suggested that users delete the temporary files remaining in their system temporary folder on (e.g., *c:\temp* folder) before/after running OFAT.

26. What is the future of OFAT?

A The following lists the plans for future developments of OFAT:

- Automate more flow models or estimation techniques (e.g., models to generate natural flow duration curves and daily flow time-series at ungauged or regulated sites, to support water-crossing design such as culverts and bridges, and to simulate rainfall-runoff events).
- Create an interface to access and analyze historical daily flow and water level data from Environment Canada's HYDAT database.
- Improve the efficiency and effectiveness of database management (e.g., organizing DEM-related databases in quaternary watersheds instead of current tertiary watersheds).
- Add new software features to enhance current OFAT capabilities (e.g., adding batch run functions for the WIES component, adding user-specified DEM functions so that user can use their own data, adding a vector-based algorithm to delineate watershed boundary in addition to the current raster-based algorithm).
- Build an interface to link OFAT with the Ontario River/Stream Ecological Classification Techniques (ORSECT). ORSECT is a GIS-based tool to automatically segment/classify a river/stream network in Ontario, based on its various landscape characteristics (e.g., slope, sinuosity, surficial geology, etc). OFAT and ORSECT will be able to share databases and functionalities as well as modelling results generated from each tool.
- Adopt new GIS technology, including migration of OFAT software from the current ArcView AVENUE programming language into ArcGIS 8.x VB/VBA.
- Develop web-based solutions for OFAT to increase accessibility to the most up-to-date flow information and spatial databases in Ontario.
- Continue to update spatial databases and perform quality control analysis on data.

Please visit the OFAT Internet site (http://nesi.mnr.gov.on.ca) or Intranet site (http://mnronline.mnr.gov.on.ca/spectrasites/nesi/nesihomepage.cfm) to get the most updated information about OFAT, including news, upgrades, user discussion forum, etc.

Troubleshooting

This chapter will help the user solve technical problems encountered when running OFAT.

1. **OFAT installation did not successfully complete.**

   A Please re-install the OFAT software and/or databases using the OFAT CDs.

2. **I do not see the OFAT shortcut on the desktop after installation.**

   A Browse to OFAT_APP\Av\Apr\ folder using Windows Explorer. Drag and drop the *OFAT.apr* file onto the desktop using the right mouse button to create the OFAT shortcut. Once created, you can double-click the shortcut to start OFAT.

3. **ArcView can not find Spatial Analyst when OFAT starts.**

   A Make sure Spatial Analyst has been properly installed on your computer. If Spatial Analyst is on your computer but ArcView still can not find it, browse to the *spatial.avx* file when prompted.

4. **A message, stating that OFATDATA environment variable and OFATDATA.txt file does not exist, appears when OFAT starts.**

   A Please re-install the OFAT software using the OFAT Setup CD.

5. **OFAT won't open or run properly.**

   A Make sure that your computer hardware and software meet the minimum system requirements of OFAT. To run OFAT, you need ArcView 3.2a (with the patch) with Spatial Analyst 2.0. Also, make sure that OFAT software and/or databases have been properly installed. If the problem persists, you may need to re-install the OFAT software or/and databases using the OFAT CDs.

6. **The Watershed Calculator runs but the results are not shown.**

   A Check to see how many other ArcView extensions you have loaded. To check loaded extensions, select the 'Extensions' menu item from the 'File' pull down menu. The only necessary extension for OFAT is Spatial Analyst. Turn off all other extensions, particularly the Digitizer and Modelbuilder extensions.

7. **When running the Flow Prediction Models, some error messages occur.**

   A Make sure the model folder (i.e., OFAT_APP\Model\) is present. If not, re-install the OFAT software using the Setup CD. If the problem persists, some data files used by the models may be missing or corrupted. In this case, re-install the OFAT databases using the OFAT CDs.

8. **When setting up a batch run, an error message appears: "ERROR. Script 'OFAT.dlgBatchlbtClick' is already in the process of being executed."**

   A This occurs because OFAT has not had time to catch up with the user's selections. Click 'OK' on the error message and wait for OFAT to finish its current process. Proceed as normal.

9. **I'm having problems with the Batch Run.**

   A If problems persist when executing the Batch Run, it is recommended that OFAT be exited and re-started.

10. **The imported database does not geographically match the OFAT data.**

    A Make sure the imported data for a selected major basin is in the appropriate projection. Please see Appendix A for the projection used for each major basin.

Glossary

AMC – antecedent moisture condition (see Appendix C for more details)

ASCII file – a file containing only American Standard Code for Information Interchange (ASCII) characters (i.e., no pictures or formatting codes) for representing alphanumeric information, allowing different makes and models of computers to communicate with one another

Bankfull flow – flow corresponds to bankfull stage at which water just begins to enter onto the floodplain

Base flow – portion of flow in a stream derived from soil moisture or ground water

Basin Index Map of Ontario – an interactive map that displays the 13 major basins of Ontario; helps narrow down the watershed outlet of interest

Batch Run – a component included in OFAT that allows the delineation, parameter calculations, and flow modelling for multiple (or single) watersheds in the same batch run without constant user interventions

Calculated drainage – see raster-based drainage network

Cell resolution – the amount of earth surface covered by a single grid cell in a raster-based data structure, specified in units of metres, kilometres, or simple relative units

Centroid – refers to a watershed centroid in OFAT whose co-ordinates can be determined by using the following 'centre of gravity' or 'centre of mass' formula:

$$c_x = \frac{1}{6A}\sum_{i=0}^{N-1}(x_i + x_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

$$c_y = \frac{1}{6A}\sum_{i=0}^{N-1}(y_i + y_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

where c_x and c_y are the x and y co-ordinates of watershed centroid, respectively; and x_i and y_i are the x and y co-ordinates of the i^{th} vertice of the polygon representing watershed boundary, respectively

cms – cubic meters per second

CN – see Runoff Curve Number

Coverage – coverage refers to an ArcInfo coverage, a database that stores geographic and tabular data in a set of files stored within a common directory

Database – a collection of data stored and arranged for ease and speed of expansion, update, search, and retrieval

dBase file – a database file saved in dBase format (e.g., **.dbf*) that can be manipulated by most commonly used database management systems

Delimited text file – an ASCII text file that contains string or/and numeric values separated by a delimiter (e.g., a comma, space, etc.)

Delineated watershed – refers to a watershed whose boundary is delineated using the 'Watershed Delineation' component of OFAT

DEM – see Digital Elevation Model

Digital Elevation Model (DEM) – a matrix consisting of a data file representing a topographic surface arranged as a set of regularly spaced (x, y) co-ordinate locations where each cell contains an elevation value

Discharge – a volume of flow per unit of time passing a point of interest, expressed in cubic meters per second (cms or m^3/s) in the metric system

Flood – a flow event that causes a river, lake, or other water bodies to rise above normal non-damaging limits

Flow – see discharge

Flow accumulation grid – a grid that is derived from the flow direction grid; a cell value of flow accumulation grid representing the number of "upstream" cells whose flow path passes through the cell (i.e., high accumulation values indicating points in the stream, whereas low values indicating areas of overland flow)

Flow direction grid – a grid that is derived from the DEM; a cell value of flow direction grid indicating the direction of the steepest descent from the cell (i.e., identifying which neighbouring cell has the lowest elevation)

Flood frequency curve – a curve that shows the relationship between flood magnitudes and corresponding return periods in years

Frequency – the number of observations of a random variable

Geographic Information System (GIS) – a system which is the collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, retrieve, manipulate, analyze, and display all forms of geographically referenced information

GIS – see Geographic Information System

Grid – a group of square cells (each cell having an attached value) arranged in rows and columns in the raster-based GIS data structure

Hydrologic model – see regional hydrologic models

IFR – see instream flow requirements

Index flood – the flood magnitude, generally the mean annual flood, used in the index flood method

Index flood method – a simple regionalization technique that assumes the probability distribution of floods at different sites in hydrologically homogeneous region are the same except for a scale or index flood parameter (generally the mean annual flood) which reflects the size, meteorological, and physiographic characteristics of each watershed

INFO file – a database file that contains the attribute information of an ArcInfo coverage

Instream flow requirements – flows in a regulated stream channel that are required to enhance, or at least maintain, aquatic resources at various designated levels such as optimal, outstanding, excellent, good, fair or degrading, etc.

Layer – an integrated, logical, areal distributed set of thematic spatial data, usually organized by subject matter

Low flow – the dry-season stream flow that, in the absence of rain and/or snowmelt, is sustained by discharge from groundwater

Major Basin – refer to any of 13 major basins of Ontario (e.g., the Moose River Basin, the Lake Superior Basin, etc.)

Mean annual flow – the average value of annual flows for a watershed

Metadata – information about data (e.g., source of data, scales, etc.)

NAD83 CNT – a reference system (datum) for North America derived in 1983 with a Canadian National Transformation

NRVIS – the Natural Resource and Values Information System of the Ontario Ministry of Natural Resources

NTS – National Topographic Series

OBM – Ontario Base Map

Outlet – see watershed outlet

Pour point – see watershed outlet

Projection – a mathematical model that transforms the locations of features on the earth's surface from three-dimensional spherical to two-dimensional planar co-ordinates, allowing flat maps to depict three-dimensional features; some map projections preserve the integrity of shape, others preserve accuracy of area, distance, or direction

Q – symbol for discharge/flow

Raster – a cellular GIS data structure that is compose of uniformly spaced rows and columns; groups of cells represent features on the earth's surface, and the value assigned to each cell represents the value of the feature

Raster-based drainage network – the drainage network derived from a flow accumulation grid

Regional hydrologic models – refer to the mathematical models included in OFAT that have been developed for different hydrologically homogeneous regions in Ontario, based on streamflow information from provincial hydrometric gauging stations; the models can be used to determine the magnitude and frequency of floods or low flows for ungauged watersheds located within a hydrologically homogeneous region

Resolution – see cell resolution

Return period – the time interval for which an event of a given quantity will occur once on the average

RIMS – the River Information Management System, developed by the Ontario Ministry of Natural Resources, which is an interactive, GIS-based application to manage multimedia information (including text, figures, tables, maps, photos/images, video and sound clips) pertaining to rivers/watersheds

Runoff Curve Number – an index of runoff potential, ranging from 0 to 100, which can be determined based on land cover/use type, hydrologic soil group (or soil drainage), and antecedent moisture condition; see Appendix C for details

Selected Watershed Area Map – an interactive map that displays the selected tertiary watershed (contains layers such as the DEM); can be zoomed into for selection of a watershed outlet of interest

Shapefile – the native ArcView spatial data format

Tertiary watershed – a watershed used for organizing DEM-related databases of OFAT (e.g., 4LA, 4LB, etc.)

Tertiary Watershed Index Map – an interactive map that displays the tertiary watersheds of the selected major basin; helps narrow down watershed outlet of interest

Text file – see ASCII file

Unit-flood – the ratio of a flood flow to drainage area in cubic meters per second per square kilometre (i.e., cms/km^2)

Unit-high flow – see unit-flood

Unit-low flow – the ratio of a low flow to drainage area in cubic meters per second per square kilometre (i.e., cms/km^2)

Universal Transverse Mercator (UTM) – a widely used planar co-ordinate system based on a specialized application of the Transverse Mercator projection. The extent of the co-ordinate system is broken into 60, 6-degree zones. Within each zone, co-ordinates are usually expressed as meters north or south of the equator and east from a reference axis.

UTM – see Universal Transverse Mercator

View – refer to an interactive map created in ArcView GIS, which contains a collection of data layers that share a common co-ordinate system and usually a common spatial extent as well

Watershed – a region or area bounded peripherally by a topographic divide that ultimately drains to a particular watercourse or water body

Watershed Calculator – a component included in OFAT, that can be used to calculate various hydrologic parameters for the delineated watershed

Watershed Delineation – a component included in OFAT, that automatically derives watershed boundary for a watershed outlet, based on DEM-related databases

Watershed Information Extraction Map – a map in OFAT that displays selected layers clipped to the boundary of the delineated watershed in the WIES component

Watershed Information Extraction System – a component included in OFAT that extracts selected data layers to the boundary of the delineated watershed, and generates charts and summary statistics for the layers within the watershed

Watershed outlet – the pour point of a watershed; all water from that watershed flows into that point

Watershed parameters – physiographic and climatic parameters pertaining to the delineated watershed, which can be calculated by the Watershed Calculator and are required for running flow models included in OFAT; see Appendix B for detailed description of each parameter

WIES – see Watershed Information Extraction System

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Appendix A: Corresponding UTM Zones for Major Basins of Ontario

The OFAT spatial database, pertaining to each of the major basins of Ontario, is in the UTM projection (NAD83 CNT) with an assigned UTM zone. In reality, some parts of the basin may extend into more than one zone. However, since data layers can only contain one projection, the basin has been assigned to the zone in which most of its area falls within. Please refer to the following table and map for information about the UTM zones assigned to the13 major basins:

Name of Major Basin	**UTM Zone**
Albany River Basin	16
Attawapiskat River Basin	16
Ekwan River Basin	16
Lake Erie Basin	17
Lake Huron Basin	17
Lake Ontario Basin	17
Lake Superior Basin	16
Moose River Basin	17
Nelson River Basin	15
Other Basins	16
Ottawa River Basin	18
Severn River Basin	15
Winisk River Basin	16

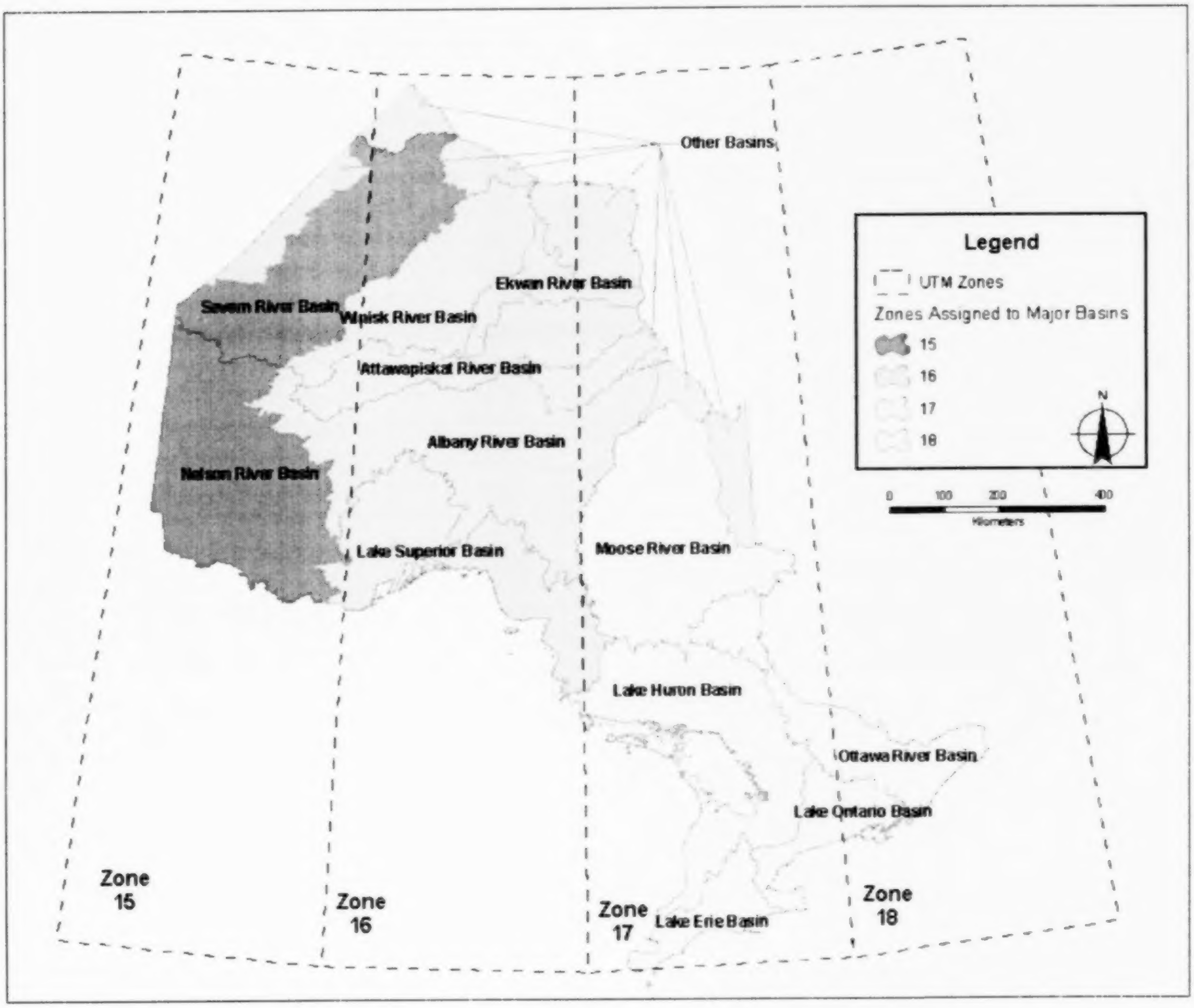
Other Basins
Legend
UTM Zones
Zones Assigned to Major Basins
15
16
17
18
N
0
100
200
400
Kilometers
Ekwan River Basin
Severn River Basin
Winisk River Basin
Attawapiskat River Basin
Albany River Basin
Nelson River Basin
Lake Superior Basin
Moose River Basin
Lake Huron Basin
Ottawa River Basin
Lake Ontario Basin
Lake Erie Basin
Zone 15
Zone 16
Zone 17
Zone 18

Figure: Major Basins of Ontario and Corresponding UTM Zones.

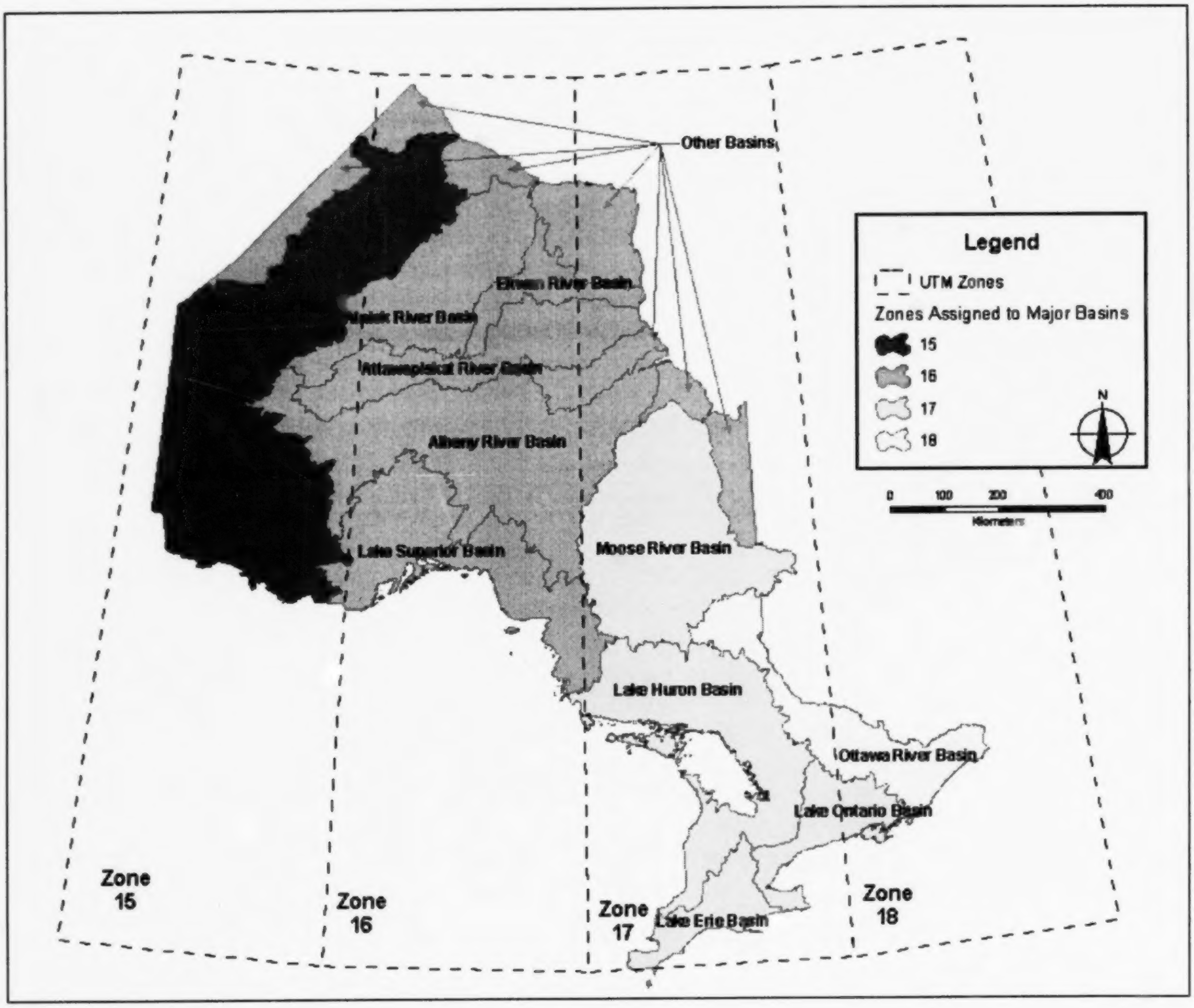
Other Basins
Ekwan River Basin
Winisk River Basin
Attawapiskat River Basin
Albany River Basin
Lake Superior Basin
Moose River Basin
Lake Huron Basin
Ottawa River Basin
Lake Ontario Basin
Lake Erie Basin
Zone 15
Zone 16
Zone 17
Zone 18
Legend
UTM Zones
Zones Assigned to Major Basins
15
16
17
18
N
0
100
200
400
Kilometers

Figure: Major Basins of Ontario and Corresponding UTM Zones.

Appendix B: Watershed Calculator Parameter Descriptions

Symbol	**Parameter**	**Description**	**Units**
ACLS	Percentage of Water and Wetland Cover in a Watershed	The percentage of area covered by lakes and wetlands within the delineated watershed.	dimensionless (represented in %)
BFI	Base Flow Index	The ratio of base flow to total flow volume.	dimensionless
BR	Basin Relief	The total change in elevation for the watershed.	m
CN_I	U.S. Soil Conservation Service (SCS) Runoff Curve Number (CN) under Antecedent Moisture Condition (AMC) I	The average CN value within the watershed under dry antecedent moisture condition based on 5-day antecedent precipitation. See Appendix C for a more detailed description.	dimensionless
CN_{II}	U.S. SCS Runoff Curve Number under AMC II	The average CN value within the watershed under average antecedent moisture condition based on 5-day antecedent precipitation. See Appendix C for a more detailed description.	dimensionless
CN_{III}	U.S. SCS Runoff Curve Number AMC III	The average CN value within the watershed under wet antecedent moisture condition based on 5-day antecedent precipitation. See Appendix C for a more detailed description.	dimensionless
DA	Drainage Area	The area of the delineated watershed.	km^2
EVA	Mean Annual Lake Evaporation	The average amount of annual evaporation from lakes within the delineated watershed.	mm
Lca	Main Channel Length from Watershed Outlet to Watershed Centroid	The length of the main channel (longest calculated drainage line), from the watershed outlet to the point on the main channel that is closest to the watershed centroid.	km
LNTH	Length of Main Channel	The length of the longest calculated drainage line within the derived watershed.	km

Symbol	Parameter	Description	Units
MAP	Mean Annual Precipitation	The average amount of annual precipitation within the delineated watershed.	mm
MAR	Mean Annual Runoff	The average amount of annual runoff within the delineated watershed.	mm
MAS	Mean Annual Snowfall	The average amount of annual snowfall within the delineated watershed.	cm
MaxE	Maximum Watershed Elevation	The maximum elevation value of the DEM within the delineated watershed.	m
ME	Mean Elevation	The average elevation value of the DEM within the delineated watershed.	m
MFD	Maximum Flow Distance	The longest path of water from the watershed outlet to the watershed divide.	km
MinE	Minimum Watershed Elevation	The minimum elevation of the DEM within the delineated watershed.	m
MSW	Mean Slope of Watershed	The average slope of the watershed in percentage (%) calculated using the slope grid.	dimensionless (represented in %)
P	Perimeter	The total length along the watershed boundary.	km
SF	Shape Factor	The square of the length of the main channel divided by the drainage area.	dimensionless
SLP	Slope of Main Channel	The slope of the longest channel within the delineated watershed.	dimensionless (represented in m/km)

Appendix C: Runoff Curve Number (CN)

The Soil Conservation Service (SCS) of the U.S. Department of Agriculture developed the runoff Curve Number (CN) method to compute the precipitation loss from storm rainfall. The details about the CN method can be found in the "National Engineering Handbook, Section 4, Hydrology" (SCS, 1972). The CN, ranging from 0 to 100, is an index of runoff potential and is inversely proportional to the precipitation loss within a watershed (infiltration into the ground and interception by land cover). The greater the CN value, the higher the runoff potential and the lower the precipitation loss.

The major factors that determine CN are the land cover/use type, hydrologic soil group (or soil drainage), and antecedent moisture condition (AMC). The Watershed Calculator and Watershed Information Extraction System (WIES) of OFAT can automatically calculate and summarize the average CN values of different AMCs for a delineated watershed. Although the calculated CN values are not used for any regional flow models currently included in OFAT, they are important hydrologic information for estimation of runoff potential, which can be used by other hydrologic models.

The land cover database used in OFAT, based on the Ontario Land Cover Data Base of 25m resolution grid (MNR, 1997), contains 28 classes as follows:

Land Cover ID	**Description**
1	Water
2	Coastal Mudflats
3	Intertidal Marsh
4	Supertidal Marsh
5	Freshwater Coastal Marsh / Inland Marsh
6	Deciduous Swamp
7	Conifer Swamp
8	Open Fen
9	Treed Fen
10	Open Bog
11	Treed Bog
12	Tundra Heath
13	Dense Deciduous Forest
14	Dense Coniferous Forest
15	Coniferous Plantation
16	Mixed Forest – mainly Deciduous
17	Mixed Forest – mainly Coniferous
18	Sparse Coniferous Forest
19	Sparse Deciduous Forest
20	Recent Cutovers
21	Recent Burns
22	Old Cuts and Burns
23	Mine Tailings, Quarries, and Bedrock Outcrop
24	Settlement and Developed Land
25	Pasture and Abandoned Fields
26	Cropland
27	Alvar
28	Unclassified (Cloud & Shadow)

The soil drainage database used in OFAT is based on the Soil Landscape of Canada (SLC) Version 2.2 at a scale of 1:1,000,000 (Agriculture and Agri-Food Canada, 1996). It should be noted that the Canadian classification system for soil drainage is different from the one defined by the SCS (1972). The Canadian system has six soil drainage classes defined as follows:

1. Rapidly drained
2. Well drained
3. Moderately drained
4. Imperfectly drained
5. Poorly drained
6. Very poorly drained

However, the SCS has classified U.S. soils into four hydrologic soil groups (A, B, C, and D), according to their infiltration rate. The Group A soils have higher water transmission rates and low runoff potential while the Group D soils have a very low water transmission rates and high runoff potential. To correlate the Canadian classification system with the U.S. SCS system, an empirical relationship derived by Pomeroy (1987) has been used by OFAT. The relationship between the U.S. and Canadian soil drainage classification systems is as follows:

Canadian Classification	U.S. SCS Classification
Rapidly	A
Well	B
Moderately Well	C
Imperfect	C
Poorly	C
Very Poorly	D

The CN method uses an antecedent rainfall index (i.e., 5-day antecedent precipitation) to estimate AMC. AMC I, AMC II, and AMC III represent dry, average, and wet antecedent moisture conditions, respectively. AMC I has the lowest runoff potential while AMC III has the highest. The SCS (1972) has developed a series of tables for CN values to represent average antecedent runoff conditions (AMC II) for various combinations of land cover/use and hydrologic soil groups. Hawkins *et al.* (1985) derived the equations to directly compute CN values for AMC I and AMC III from CN values of AMC II as follows:

$$CN_{I} = \frac{CN_{II}}{2.281 - 0.01281 * CN_{II}}$$

and

$$CN_{III} = \frac{CN_{II}}{0.427 + 0.00573 * CN_{II}}$$

CN_{I}, CN_{II}, and CN_{III} are runoff curve numbers for AMC I, AMC II, and AMC III, respectively.

The following CN_{II} reference table lists the CN values of average antecedent moisture condition for possible combinations of land cover and soil drainage classification encountered in Ontario. The CN_{II} values assigned in the table are cited directly, if applicable, or extrapolated from CN tables suggested by SCS (1972), the U.S. Bureau of Reclamation (1976), and Chang (1992).

Land Cover ID (28 classes)	**Description**	**U.S. SCS Soil Drainage Class**			
		A	**B**	**C**	**D**
1	Water	100	100	100	100
2	Coastal Mudflats	55	75	84	90
3	Intertidal Marsh	55	75	84	90
4	Supertidal Marsh	55	75	84	90
5	Freshwater Coastal Marsh / Inland Marsh	55	75	84	90
6	Deciduous Swamp	45	66	77	83
7	Conifer Swamp	45	66	77	83
8	Open Fen	55	75	84	90
9	Treed Fen	45	66	77	83
10	Open Bog	55	75	84	90
11	Treed Bog	45	66	77	83
12	Tundra Heath	45	66	77	83
13	Dense Deciduous Forest	36	60	70	76
14	Dense Coniferous Forest	26	52	62	69
15	Coniferous Plantation	26	52	62	69
16	Mixed Forest – mainly Deciduous	36	60	70	76
17	Mixed Forest – mainly Coniferous	26	52	62	69
18	Sparse Coniferous Forest	46	68	78	84
19	Sparse Deciduous Forest	46	68	78	84
20	Recent Cutovers	56	75	86	91
21	Recent Burns	56	75	86	91
22	Old Cuts and Burns	46	68	78	84
23	Mine Tailings, Quarries, and Bedrock Outcrop	100	100	100	100
24	Settlement and Developed Land	60	74	83	87
25	Pasture and Abandoned Fields	54	70	80	85
26	Cropland	54	70	80	85
27	Alvar	54	70	80	85
28	Unclassified (Cloud & Shadow)	N/A	N/A	N/A	N/A

The provincial CN database, based on the above CN_{II} cross-reference table, has been generated by the OFAT project by overlaying the provincial land cover and soil drainage GIS databases. A CN_{II} value is assigned to each 25m*25m grid cell, depending on the combination of land cover class and soil drainage class for each cell. The resulting CN_{II} database can then be used to calculate CN values for dry and wet antecedent moisture conditions (i.e., CN_{I} and CN_{III}, respectively) by using the equations proposed by Hawkins *et al.* (1985) as mentioned earlier.

Appendix D: Hydrological Models

Model Categories

1. Low Flow Prediction Models (LOF)
2. Flood Prediction Models (HIF)
3. Mean Annual Flow Prediction Models (MAF)
4. Minimum Instream Flow Requirements Models (IFR)
5. Bankfull Discharge Prediction Models (BFQ)

1. Low Flow Prediction Models (LOF)

Four low flow prediction models for Ontario were developed by the MOEE (1995). Ontario was divided into six regions with low-flow equations developed for each region:

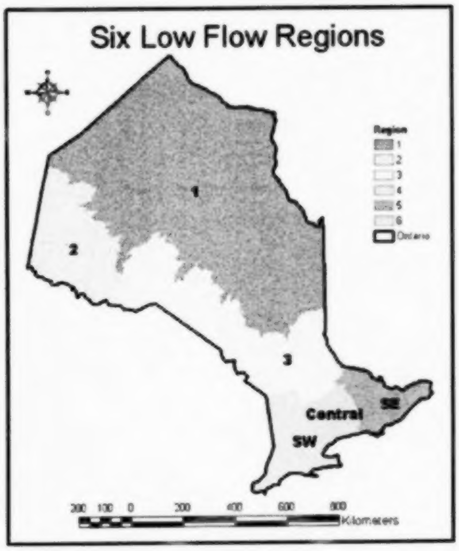

Figure: Six Low Flow Regions in Ontario (MOEE, 1995).

Isoline Method (MOEE, 1995)

1-, 3-, 7-, 15-, and 30-day average low flows of 1.005-, 1.01-, 1.111-, 1.25-, 2-, 5-, 10-, 20-, 50-, 100-, and 200-year return period (i.e., $1Q_{1.005}$, $1Q_{1.111}$, $1Q_{1.25}$,...$30Q_{200}$) derived at provincial hydrometric gauging stations were divided by the station's drainage area to obtain unit-low flows in cms/km^2 (i.e., $1q_{1.005}$, $1q_{1.111}$, $1q_{1.25}$,.....$30q_{200}$). The 1km*1km resolution grids were created by interpolating the unit-low flow point data at the hydrometric stations. Using OFAT, the low flows at an ungauged watershed can be estimated by multiplying the drainage area with the average unit-low flow values within the watershed boundary.

Graphical Index Method (MOEE, 1995)

Northern, Central and Southeastern Regions

The index low flow, $7Q_2$, is strongly correlated to and can be estimated by drainage area (DA). The following table lists the equations used to estimate $7Q_2$ for the three regions in northern Ontario, the Central and Southeastern regions:

Region	Equation
1	$7Q_2 = 8.681 + 0.00208 * DA$
2	$7Q_2 = -2.494 + 0.00325 * DA$
3	$7Q_2 = -1.341 + 0.00353 * DA$
Central Region	$7Q_2 = 0.383 + 0.00161 * DA$
Southeastern Region	$7Q_2 = -1.60 + 0.00251 * DA$
Combined Central and Southeastern Regions	$7Q_2 = 0.118 + 0.00205 * DA$

After $7Q_2$ is estimated for a watershed, 3-, 7-, 15-, and 30-day low flows of 2-, 5-, 10-, 20-, 50-, and 100-year return period can then be estimated using a series of graphs included in the original report (MOEE, 1995).

Southwestern and West Central Regions

The index low flow, $7Q_2$, is strongly correlated to drainage area (DA). $7Q_2$ can be estimated by using the $7Q_2$ - DA relationship included in the original report (MOEE, 1995). After $7Q_2$ is estimated for a watershed, 3-, 7-, and 30-day low flows of 2-, 5-, 10-, 20-, 50-, and 100-year return period can then be estimated using a series of graphs included in the original report (MOEE, 1995).

Statistical Index Method (MOEE, 1995)

Northeastern and Northwestern Regions

To use this method for predicting low flows for ungauged watersheds, OFAT first uses the regression method to estimate the index low flow $7Q_2$. Next the regional parameters of Weibull III distribution for the sub-region (i.e., Regions 1, 2, or 3) in which the site is located are identified from the following table:

Region	Duration (days)	a	e	u
1	1	1.952	0.341	1.136
	3	2.150	0.349	1.121
	7	1.272	0.403	1.105
	15	2.031	0.407	1.117
	30	1.095	0.424	1.116
2	1	1.362	0.090	1.281
	3	1.484	0.089	1.255
	7	1.772	0.050	1.190
	15	1.694	0.078	1.223
	30	1.842	0.104	1.197
3	1	1.400	0.194	1.241
	3	1.610	0.190	1.207
	7	1.580	0.221	1.203
	15	1.605	0.239	1.195
	30	1.503	0.259	1.205

The following equation is used to estimate the regional quantile with return period y:

$$q_y = e + (u-e) * \{-\ln[1 - 1/y]\}^{1/a}$$

The low flows for various durations of y-year return periods can then be estimated by:

$$Qy = 7Q_2 * q_y$$

Central, Southeastern, Southwestern and West Central Regions

The Statistical Index Method is not available in these regions.

Regression Method (MOEE, 1995)

Northeastern and Northwestern Regions

The following parameters are used in the final regression:

Variables	Symbol
Drainage Area (km^2)	DA
Length of main channel (km)	LNTH
Mean Annual Runoff (mm)	MAR

The general form of multiple regression equation to estimate $7Q_2$ and $7Q_{20}$ is:

$$Y = a_0 + a_1(DA) + a_2(DA)^{1/2} + a_3(DA)^2 + a_4(LNTH) + a_5(LNTH)^{1/2} + a_6(MAR) + a_7(MAR)^2$$

The following table lists multiple regression equations for $7Q_2$:

Region	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7
1	-35.766		0.8628			-4.130		0.000353
2	21.65	0.00337				-4.791	0.1088	
3	7.506			1.581×10^{-7}		0.5491	-0.0156	
1,2 and 3 DA<17000 km^2	-3.15	0.00323			-0.01898		0.00756	

The following table lists multiple regression equations for $7Q_{20}$:

Region	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7
1	-25.718		0.5587			-2.89		0.000272
2	8.124	0.00125				-0.796	-0.0104	
3	0.4185			9.777×10^{-8}		0.3403	-0.0055	
1,2 and 3 DA<17000 km^2	-2.45	0.0016			-0.0021		0.0047	

Central and Southeastern Regions

The following parameters are used in the final regression for both regions:

Variables	Symbol
Drainage Area (km^2)	DA
Base Flow Index (dimensionless)	BFI

The general form of multiple regression equation to estimate various low flows for the Central Region is:

$$Y = a_0 + a_1(DA) + a_2(BFI)$$

The following table lists multiple regression equations in the Central Region:

Flow (cms)	a_0	a_1	a_2
$7Q_{20}$	-0.2134	0.00066184	0.7022
$7Q_2$	-0.7216	0.0018060	1.7386
$3Q_2$	-0.5398	0.0016260	1.2856
$3Q_{20}$	-0.1841	0.00058893	0.6295
$3Q_{50}$	-0.1331	0.00045199	0.5160
$30Q_2$	-0.7119	0.0022380	1.6806
$30Q_{20}$	-0.3275	0.00097749	0.9305
$30Q_{50}$	-0.2839	0.00087086	0.8045

The general form of multiple regression equation to estimate various low flows for the Southeastern Region is:

$$Y = a_0 + a_1(DA)^3 + a_2(BFI)$$

The following table lists multiple regression equations in the Southeastern Region:

Flow (cms)	a_0	a_1	a_2
$7Q_{20}$	-0.5084	7.6323E-11	1.1460
$7Q_2$	-0.9018	1.3049E-10	2.2728
$3Q_2$	-1.0351	1.2409E-10	2.3828
$3Q_{20}$	-0.6133	7.0980E-11	1.2527
$3Q_{50}$	-0.6226	6.5153E-11	1.2372
$30Q_2$	-1.0195	1.4637E-10	2.6144
$30Q_{20}$	-0.5196	8.5495E-11	1.3062
$30Q_{50}$	-0.4643	7.9836E-11	1.1773

Southwestern and West Central Regions

The following parameters are used in the final regression for these regions:

Variables	**Symbol**
Drainage Area (km^2)	DA
Base Flow Index (dimensionless)	BFI
Length of main channel (km)	LNTH
Mean Annual Runoff (mm)	MAR
Mean Annual Snow (cm)	MAS

The general form of multiple regression equation to estimate various low flows for these regions is:

$$Y = a_0 + a_1(DA)^3 + a_2(BFI)^2 + a_3\,(LNTH)^2 + a_4\,Log(MAR) + a_5\,Log(MAS)$$

The following table lists multiple regression equations for the regions:

Flow (cms)	a_0	a_1	a_2	a_3	a_4	a_5
$7Q_2$	-0.190	1.24 E-10	1.67	8.35E-5		
$7Q_{20}$	-0.166	9.03E-11	1.10	4.67E-5		
$7Q_{50}$	-0.160	8.54E-11	1.02	3.92E-5		
$3Q_2$	-0.183	1.21E-10	1.55	7.81E-5		
$3Q_{20}$	-0.158	8.57E-11	0.99	4.30E-5		
$3Q_{50}$	-0.150	7.92E-11	0.91	3.64E-5		
$30Q_2$	-0.233	1.29E-10	2.12	1.12E-4		
$30Q_{20}$	-0.227	9.58E-11	1.52			
$30Q_{50}$	-0.078	1.25E-10	1.44			

Limitations for Low Flow Prediction Model (MOEE, 1995)

Each low flow region uses a different range of hydrologic parameters to develop models, limiting their use. The following tables show the parameter ranges used in developing the models:

Region 1

Variable	Minimum	Maximum
MAP	500	830
MAS	190	305
MAR	108	456
EVA	340	450
DA	401	94300
BFI	0	1
LNTH	25	476.3
ACLS	0	100

Region 2

Variable	Minimum	Maximum
MAP	695	790
MAS	190	230
MAR	154	406
EVA	490	515
DA	744	50200
BFI	0.68	0.99
LNTH	4	238.1
ACLS	0	100

Region 3

Variable	Minimum	Maximum
MAP	720	999
MAS	230	300
MAR	193	799
EVA	400	525
DA	8.64	47900
BFI	0.23	0.99
LNTH	3	465
ACLS	0	100

Region 4 (Central)

Variable	Minimum	Maximum
MAP	780	1000
MAS	120	300
MAR	189	527
SLP	0.02	9.434
EVA	665	830
DA	24.3	1520
BFI	0.17	0.82
LNTH	9	94.3
ACLS	0	100

Region 5 (Southeastern)

Variable	Minimum	Maximum
MAP	800	920
MAS	170	200
MAR	260	540
SLP	0.14	12.19
EVA	635	790
DA	7	4120
BFI	0.3	0.88
LNTH	5	112.4
ACLS	0	100

Region 6 (Southwestern)

Variable	Minimum	Maximum
MAP	780	1020
MAS	90	350
MAR	137	516
SLP	0.00034	0.00747
DA	14.2	3960
BFI	0.1	0.8
LNTH	6.10	190.5
ACLS	1	100

2. Flood Prediction Models (HIF)

Index Flood Method (Moin & Shaw, 1985)

In this method, the Ontario has been divided into twelve homogeneous flood regions as shown in the following figure:

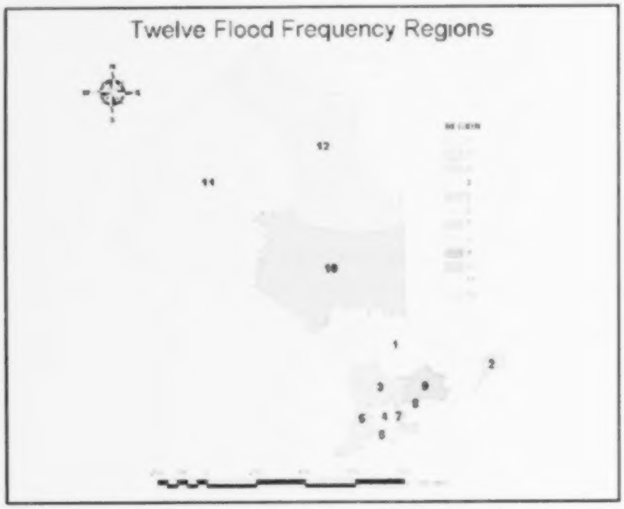

Figure: Twelve Flood Regions of Index Flood Method (Moin & Shaw, 1985).

For each flood region, the general form index flood (Q_2) can be expressed as follows:

$$Q_2 = C * A^n$$

where Q_2 = flood in a 2-year return period in cms
A = Drainage area in km^2
C = Constant
n = Exponent

Region 6 (Southwestern)

Variable	Minimum	Maximum
MAP	780	1020
MAS	90	350
MAR	137	516
SLP	0.00034	0.00747
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LNTH	6.10	190.5
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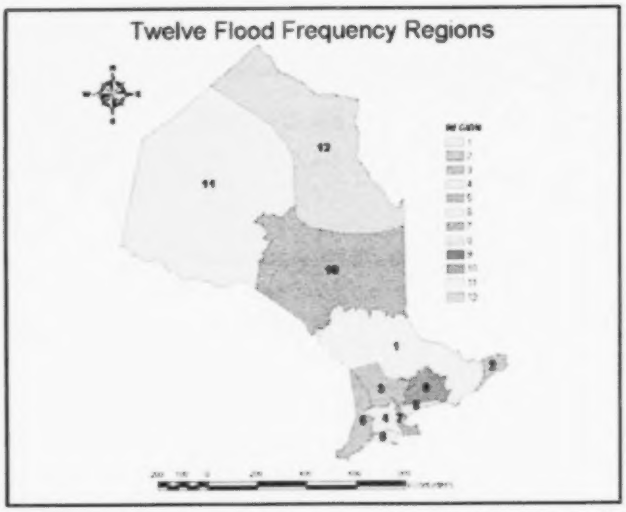

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$$Q_2 = C * A^n$$

where Q_2 = flood in a 2-year return period in cms

A = Drainage area in km^2

C = Constant

n = Exponent

The values of C and n for each of 12 flood regions are listed in the following table:

Region	**Constant C**	**Exponent n**
1(a)	0.22 ($A < 60$ km^2)	1.000
1(b)	0.73 ($A > 60$ km^2)	0.707
2	0.51	0.896
3	0.20	0.957
4	0.71	0.842
5	0.45	0.775
6	0.41	0.806
7	1.13	0.696
8	0.72	0.785
9	0.40	0.81
10	0.28	0.849
11	0.38	0.706
12	0.59	0.765

For each region, ratios of floods in different return periods (e.g., Q_{10}, Q_{20}, Q_{50}, and Q_{100}) to index flood Q_2 are represented by a regional frequency curve that can be found in the original report (Moin & Shaw, 1985). That means that floods in different return periods can be estimated from the corresponding regional frequency curve after index flood Q_2 is estimated.

The following table contains the range of drainage area (in km^2) used by each region to develop this method.

Region	**Minimum**	**Maximum**
1	0.11	9270
2	76.1	3816
3	86.0	3960
4	2.5	5910
5	14.2	4300
6	5.2	697
7	63.5	293
8	4.9	800
9	24.3	1520
10	18.6	11900
11	0.7	24200
12	4250	94300

Index Flood Method With Expected Probability Adjustment (Moin & Shaw, 1985)

Mathematically, the expected probability concept has a sound basis when applied in a regional sense. It is presumed that the frequency curves will have similar slopes in a hydrologic homogeneous region. Ontario has adopted the policy whereby all frequency distributions will be adjusted for the expected probability computation (Moin and Shaw, 1985). In this method, expected probability adjustments were made to all twelve regional index flood frequency curves. Details about this method can be found in the original report (Moin & Shaw, 1985).

For each region, ratios of floods in different return periods (e.g., Q_{10}, Q_{20}, Q_{50}, and Q_{100}) to index flood Q_2 is represented by a regional frequency curve with expected probability adjustment that can be found in the original report (Moin & Shaw, 1985). That means that floods in different return periods can be estimated from the corresponding regional frequency curve after index flood Q_2 is estimated.

Primary Multiple Regression Method (Moin & Shaw, 1985)

In this method, Ontario has been divided into three flood regions as shown in the following figure:

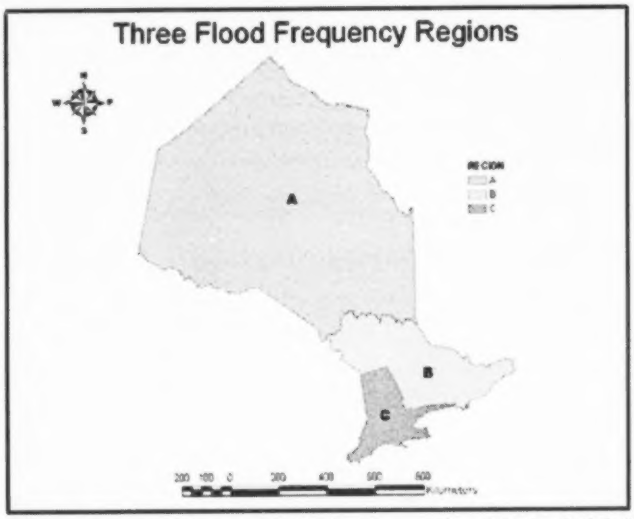

Figure: Three Flood Regions of Primary Multiple Regression Method (Moin & Shaw, 1985).

Although a number of physiographic and climatic parameters were considered, only the following parameters proved significant in the final regression:

Variables	**Symbol**
Drainage Area (km^2)	DA
Mean Channel Slope (m/km)	SLP
Index of Area Controlled by Water and Wetland (%)	ACLS
Shape Factor (dimensionless) (= $LNTH^2/DA$, where LNTH = length of main channel (km) and DA = drainage area (km^2))	SF
Base Flow Index (dimensionless)	BFI
Mean Annual Runoff (mm)	MAR
Mean Annual Precipitation (mm)	MAP

The general form of primary multiple regression equation is:

$$\begin{aligned}\mathrm{Log}(Q_T) = {} & a_0 + a_1\mathrm{Log}(DA) + a_2\,(BFI)^{1/2} + a_3\,(SLP)^{1/3} + a_4(ACLS)^{1/2} + a_5\,(SLP) + a_6\mathrm{Log}(MAR) \\ & + a_7\,(MAR) + a_8\mathrm{Log}(ACLS+1) + a_9(MAP) + a_{10}(SF)\end{aligned}$$

The following table lists primary multiple regression equations of Q_2, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} for flood region A:

Flood (cms)	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Q_2	-4.8779	0.8368		0.1796	-0.0381		1.7082				
Q_5	-1.1385	0.8303		0.2261	-0.0357			0.0020			
Q_{10}	-1.0170	0.8225		0.2521	-0.0338			0.0018			
Q_{20}	-0.9146	0.8154		0.2775	-0.0319			0.0017			
Q_{50}	-0.8641	0.8256		0.3270	-0.0243			0.0014			
Q_{100}	-0.7961	0.8208		0.3486	-0.0225			0.0013			

The following table lists primary multiple regression equations of Q_2, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} for flood region B:

Flood (cms)	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Q_2	0.4371	0.8669	-1.2282		-0.0089						
Q_5	0.5732	0.8385	-1.1327		-0.0101						
Q_{10}	0.7043	0.8110	-1.1273		-0.0105						
Q_{20}	0.5895	0.8509	-1.2714	0.1593					-0.0432		
Q_{50}	0.6412	0.8410	-1.2773	0.1978					-0.0530		
Q_{100}	0.6808	0.8337	-1.2924	0.2264					-0.0521		

The following table lists primary multiple regression equations of Q_2, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} for flood region C:

Flood (cms)	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Q_2	-2.3410	0.9976	-1.6600	0.3436			0.9347				
Q_5	-2.0193	0.9699	-1.5162	0.3591			0.8538				
Q_{10}	-1.8562	0.9514	-1.4305	0.3597			0.8178				
Q_{20}	-1.7345	0.9362	-1.3582	0.3597			0.7925				
Q_{50}	-1.3014	0.9045	-1.2890			0.0573	0.7859				
Q_{100}	-1.2500	0.8933	-1.2419			0.0575	0.7840				

Secondary Multiple Regression Method (Moin & Shaw, 1985)

Similar to the primary multiple regression equation, the general form of secondary multiple regression equation is:

$$\begin{aligned}\mathrm{Log}(Q_T) = {} & a_0 + a_1\mathrm{Log}(DA) + a_2\,(BFI)^{1/2} + a_3\,(SLP)^{1/3} + a_4(ACLS)^{1/2} + a_5\,(SLP) + a_6\mathrm{Log}(MAR) \\ & + a_7\,(MAR) + a_8\mathrm{Log}(ACLS+1) + a_9(MAP) + a_{10}(SF)\end{aligned}$$

The following table lists secondary multiple regression equations of Q_2, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} for flood region A:

Flood (cms)	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Q_2	0.5473	0.9418	-2.3038					0.0011			
Q_5	0.4916	0.8952	-1.7518					0.0012	-0.1007		
Q_{10}	0.6927	0.8859	-1.8087					0.0010	-0.0907		
Q_{20}	0.8670	0.8767	-1.8563					8.5 E-4	-0.0819		
Q_{50}	1.0335	0.9005	-2.3169							5.2 E-4	
Q_{100}	1.0929	0.8889	-2.2764							5.1 E-4	

The following table lists secondary multiple regression equations of Q_2, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} for flood region B:

Flood (cms)	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Q_2	0.2143	0.7464		-0.2172	-0.0194						-0.0077
Q_5	0.2746	0.7443		-0.1961	-0.0198						
Q_{10}	0.3795	0.7217		-0.1799	-0.0202						
Q_{20}	0.2311	0.7461			-0.0197						-0.0081
Q_{50}	0.3659	0.6989			-0.0275						
Q_{100}	0.4471	0.6839			-0.0276						

The following table lists secondary multiple regression equations of Q_2, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} for flood region C:

Flood (cms)	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}
Q_2	-1.7155	0.8734			-0.0167		0.5580				
Q_5	-1.7967	0.9031		0.1721	-0.0180		0.5424				
Q_{10}	-1.6547	0.8897		0.1841	-0.0177		0.5261				
Q_{20}	-1.5499	0.8786		0.1937	-0.0174		0.5173				
Q_{50}	-1.1793	0.8759				0.0337	0.4698		-0.0800		
Q_{100}	-1.1375	0.8676				0.0349	0.4804		-0.0811		

Limitations for Flood Prediction Models (Moin and Shaw, 1985)

The following tables contain ranges of hydrologic parameters used to develop the equations for each flood region:

All Ontario

	Q2 – Q20		Q50 – Q100	
Variable	**Minimum**	**Maximum**	**Minimum**	**Maximum**
DA	13.9	60100.0	13.9	395.5
BFI	0.15	1.00	0.15	0.56
SLP	0.02	9.42	0.02	1.22
ACLS	0.00	122.00	0.00	10.50
MAR	137.00	626.00	137.00	363.50
MAP	500.0	1000.0	500.0	840.0

Region A

	Q2 – Q20		Q50 – Q100	
Variable	**Minimum**	**Maximum**	**Minimum**	**Maximum**
DA	62.9	60100.0	62.9	118000.0
BFI	0.36	1.00	0.36	1.0
SLP	0.02	4.14	0.02	4.14
ACLS	0.00	100.00	0.00	100.00
MAR	193.00	598.00	193.00	598.00
MAP	N/A	N/A	500.0	1000.0

Region B

	Q2 – Q20		Q50 – Q100	
Variable	**Minimum**	**Maximum**	**Minimum**	**Maximum**
DA	13.9	3810.0	13.9	4770.0
BFI	0.26	0.82	0.26	0.90
SLP	0.14	5.77	0.02	5.77
ACLS	0.00	97.00	0.00	100.00
SHP	1.41	42.14	1.38	42.14

Region C

	Q2 – Q20		Q50 – Q100	
Variable	**Minimum**	**Maximum**	**Minimum**	**Maximum**
DA	14.2	5910.0	14.2	5910.0
BFI	0.15	0.81	0.15	0.81
SLP	0.21	9.42	0.21	9.42
ACLS	0.00	122.00	0.00	122.00
MAR	137.00	527.00	137.00	527.00

Multiple Regression Method (MNR, 2000)

In this method, Ontario has been divided into five flood regions, as shown in the following figure:

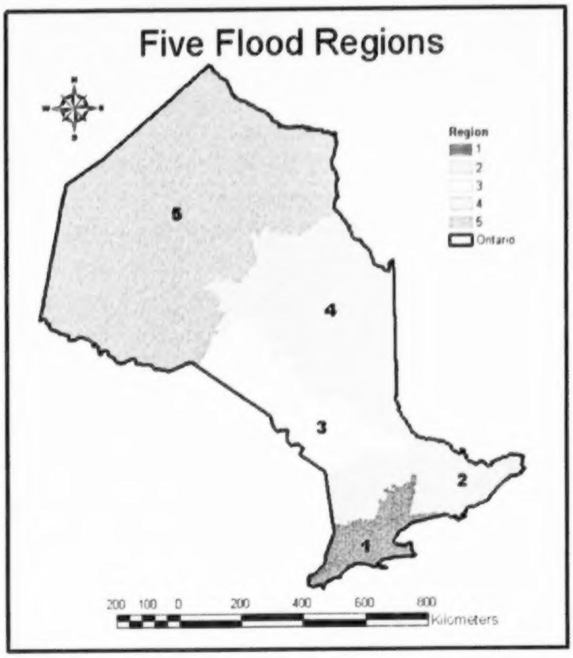

Figure: Five Flood Regions in Ontario (MNR, 2000).

The flood generating characteristics of each of five homogeneous flood regions in Ontario were used to develop regression equations to predict flood peaks Q_{20} and Q_{100} for ungauged watersheds. The climatic and physiographic variables selected for development of the regression equations are listed as follows:

Variables	**Symbol**
Drainage Area (km^2)	DA
Mean Annual Precipitation (mm)	MAP
Mean Annual Snowfall (cm)	MAS
Mean Annual Runoff (mm)	MAR
Base Flow Index (dimensionless)	BFI
Index of Area Controlled by Water and Wetland (%)	ACLS
Mean Channel Slope (m/km)	SLP
Main Channel Length (km)	LNTH
Mean Annual Evaporation (mm)	EVA

Multiple Regression Method (MNR, 2000)

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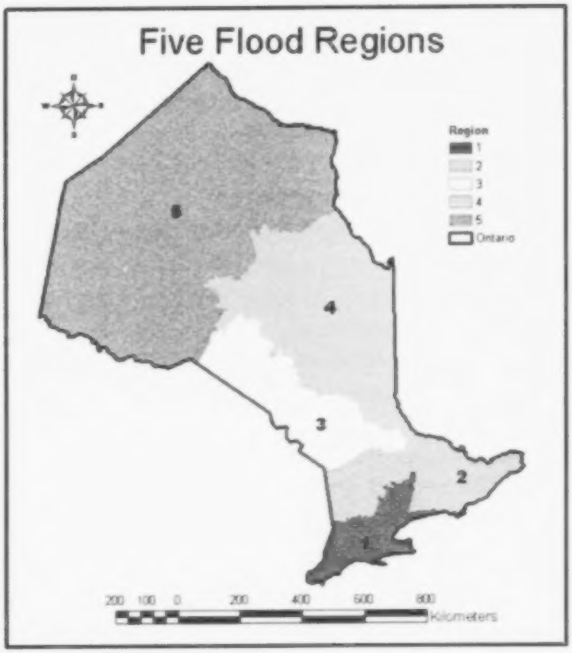

Figure: Five Flood Regions in Ontario (MNR, 2000).

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Mean Annual Runoff (mm)	MAR
Base Flow Index (dimensionless)	BFI
Index of Area Controlled by Water and Wetland (%)	ACLS
Mean Channel Slope (m/km)	SLP
Main Channel Length (km)	LNTH
Mean Annual Evaporation (mm)	EVA

The following table lists main variables used in regression equation (in Nature Logarithm Ln - form) to estimate Q_{20} and Q_{100} for each flood region:

Region	**Important Variable**
Region 1	DA, MAR, BFI, SLP, MAS
Region 2	DA, BFI, EVA
Region 3	DA,BFI, LNTH
Region 4	DA, MAR
Region 5	DA, BFI, MAS, MAR

The following table lists regression equations for Q_{20} for different flood regions:

Region	**a_0**	**a_1**	**a_2**	**a_3**	**a_4**	**a_5**	**a_6**	**a_7**	**a_8**	**a_9**
Region 1	-6.50311	1.04071		-0.44965	1.12477	-1.18165			0.35189	
Region 2	6.63186	0.92763				-1.35820				-1.32909
Region 3	-1.46476	0.70779				-1.02959	0.25610			
Region 4	-8.11137	0.85064			1.17958					
Region 5	-15.6738	0.92284		1.54533	0.84134	-1.87067				

$$\text{where } Q_{20} = a_0 + a_1 Ln(DA) + a_2 Ln(MAP) + a_3 Ln(MAS) + a_4 Ln(MAR) + a_5 Ln(BFI) + a_6 Ln(LNTH) + a_7 Ln(ACLS) + a_8 Ln(SLP) + a_9 Ln(EVA)$$

The following table lists regression equations for Q_{100} for different flood regions:

Region	**a_0**	**A_1**	**a_2**	**a_3**	**a_4**	**a_5**	**a_6**	**a_7**	**a_8**	**a_9**
Region 1	-5.98417	1.053201		-0.528969	1.133408	-1.18942			0.38408	
Region 2	6.82101	0.921807				-1.39894				
Region 3	-1.32542	0.698088				-1.12021	0.27759			
Region 4	-9.07059	0.879464			1.339485					
Region 5	-15.5088	1.056567		1.455453	0.972502	-2.06328	-0.2707			

$$\text{where } Q_{100} = a_0 + a_1 Ln(DA) + a_2 Ln(MAP) + a_3 Ln(MAS) + a_4 Ln(MAR) + a_5 Ln(BFI) + a_6 Ln(LNTH) + a_7 Ln(ACLS) + a_8 Ln(SLP) + a_9 Ln(EVA)$$

Dimensionless Flood Frequency Method (MNR, 2000)

In this method, the index flood frequency curves (i.e., Q_T/Q_2 frequency curve) for each of the five flood regions (MNR, 2000) were derived and summarized in the following table:

Region	Q_5/Q_2	Q_{10}/Q_2	Q_{20}/Q_2	Q_{50}/Q_2	Q_{100}/Q_2
Region 1	1.464128	1.757267	2.034288	2.392525	2.663892
Region 2	1.302343	1.48103	1.641315	1.838523	1.98150
Region 3	1.379202	1.611009	1.819888	2.084759	2.282126
Region 4	1.339553	1.55357	1.755341	2.015529	2.212111
Region 5	1.519678	1.85933	2.186755	2.616432	2.946388

Therefore, Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100} can be estimated by using the above table after the Q_2 value is estimated. Q_2 for each flood region can be estimated by using the equations in the following table:

Region	Regional Correlation Equation
Region 1	$\ln(Q_2) = 0.76492 * \ln(DA) - 0.27829$
Region 2	$\ln(Q_2) = 0.84944 * \ln(DA) - 1.36550$
Region 3	$\ln(Q_2) = 0.73647 * \ln(DA) - 0.69874$
Region 4	$\ln(Q_2) = 0.706116 * \ln(DA) - 0.47834$
Region 5	$\ln(Q_2) = 0.85252 * \ln(DA) - 2.23819$

Regional Flood Frequency Method (MNR, 2000)

The general principle of this method is similar to the Dimensionless Flood Frequency Method (MNR, 2000), with the main difference being that the parameters of the regional index frequency curves are calculated by empirical equations.

The frequency curves for five flood regions in Ontario (MNR, 2000) are listed in the following table:

Region	Regional Flood Frequency Curves
Region 1	$q_t = -0.19620 + \exp(0.17195 + 0.37267 * t)$
Region 2	$q_t = -0.14974 + \exp(0.13954 + 0.26534 * t)$
Region 3	$q_t = -0.20479 + \exp(0.18631 + 0.31158 * t)$
Region 4	$q_t = -0.14184 + \exp(0.15297 + 0.37182 * t)$
Region 5	$q_t = -0.09669 + \exp(0.10169 + 0.49145 * t)$

In the above table, t is the frequency factor corresponding to the return period T and $q_t = Q_T/Q_2$ where Q_T is the flood of T-year return period and Q_2 can be estimated from the same regional Q_2 equations used in the Dimensionless Flood Frequency Method (MNR, 2000). Currently, OFAT uses the Regional Flood Frequency Method to calculate Q_5, Q_{10}, Q_{20}, Q_{25}, Q_{50}, and Q_{100}. However, this method can be used to estimate a flood of any return period.

Isoline Method (MNR, 2000)

Floods (i.e., Q_5, Q_{10}, Q_{20}, Q_{50}, and Q_{100}) derived at provincial hydrometric gauging stations were divided by drainage area to obtain unit-floods in cms/km^2 (i.e., q_5, q_{10}, q_{20}, q_{50}, and q_{100}). Grids with a resolution of 1km * 1km for q_5, q_{10}, q_{20}, q_{50}, and q_{100} were created by interpolating unit-floods point data at the hydrometric stations. Using OFAT, the flood flows at an ungauged watershed can be estimated by multiplying the drainage area with the average unit-flood values within the watershed boundary.

Limitations for Flood Prediction Models (MNR, 2000)

The following table lists each region and ranges of watershed parameters used in developing the flood prediction models.

Parameter	**Region**											
	Ontario		**Region 1**		**Region 2**		**Region 3**		**Region 4**		**Region 5**	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
DA	0.1	94300	2.51	3700	0.1	9090	2.1	4270	37.3	8940	0.3	943000
MAP	500	1000	780	1000	790	1000	790	1000	720	880	500	805
MAS	90	350	90	300	110	350	230	310	220	300	180	260
MAR	137	826	137	480	255	540	240	826	245	679	154	406
EVA	340	820	550	820	510	780	490	525	380	500	340	515
BFI	0.1	0.99	0.1	0.82	0.27	0.88	0.27	0.9	0.15	0.86	0.36	0.99
MCL	3.0	465	5.5	100.9	5.0	190.5	4.5	465	3.0	335.6	15.0	419.7
ACLS	0	100	0	100	0	100	10	100	0	100	0	100
SLP	0.34	9.4	0.34	9.4	0.04	7.1	0.43	1.7	0.11	4.4	0.5	0.9

3. Mean Annual Flow Prediction Models (MAF)

Currently, OFAT contains the Isoline Method (Environment Canada, 1986) to estimate mean annual flow (cms). The original provincial isoline map for mean annual runoff (mm) was first digitized and then a continuous surface (a map) with 1km * 1km cell resolution was created from the isolines. The mean annual runoff (mm) for the watershed is calculated by averaging all the cell values within the watershed boundary, which can be converted into mean annual flow (cms).

4. Minimum Instream Flow Requirement Models (IFR)

The Tennant Method or Montana Method (Tennant, 1976) provides a quick and easy methodology for determining flows to protect the aquatic resources in both warm water and cold water streams. It is based on the ratio of the various flow ratings to the mean annual flow for the periods of October to March and April to September, as shown in the following table. In OFAT, the mean annual flow is estimated by using the Isoline Method (Environment Canada, 1986).

Table: Flow ratings as percent of Mean Annual Flow.

Flow Rating	**October to March**	**April to September**
Flushing to Maximum	200 percent	200 percent
Optimal Range	60-100 percent	60-100 percent
Outstanding	40 percent	60 percent
Excellent	30 percent	50 percent
Good	20 percent	40 percent
Fair or Degrading	10 percent	30 percent
Poor or Minimum	10 percent	10 percent
Severe Degradation	< 10 percent	< 10 percent

5. Bankfull Discharge Prediction Models (BFQ)

Most commonly, bankfull discharge corresponds to floods occurring in 1 to 2-year return period. In OFAT, the Index Flood Method (Moin & Shaw, 1985) has been used to estimate n-year return period flood corresponding to bankfull discharge used in the following models.

Annable Bankfull Discharge Model (Annable, 1994)

Annable (1994) estimated that the bankfull discharge corresponds to 1.6-year return period based on his study on rivers in southwestern Ontario.

Leopold Bankfull Discharge Model (Leopold *et al.*, 1964)

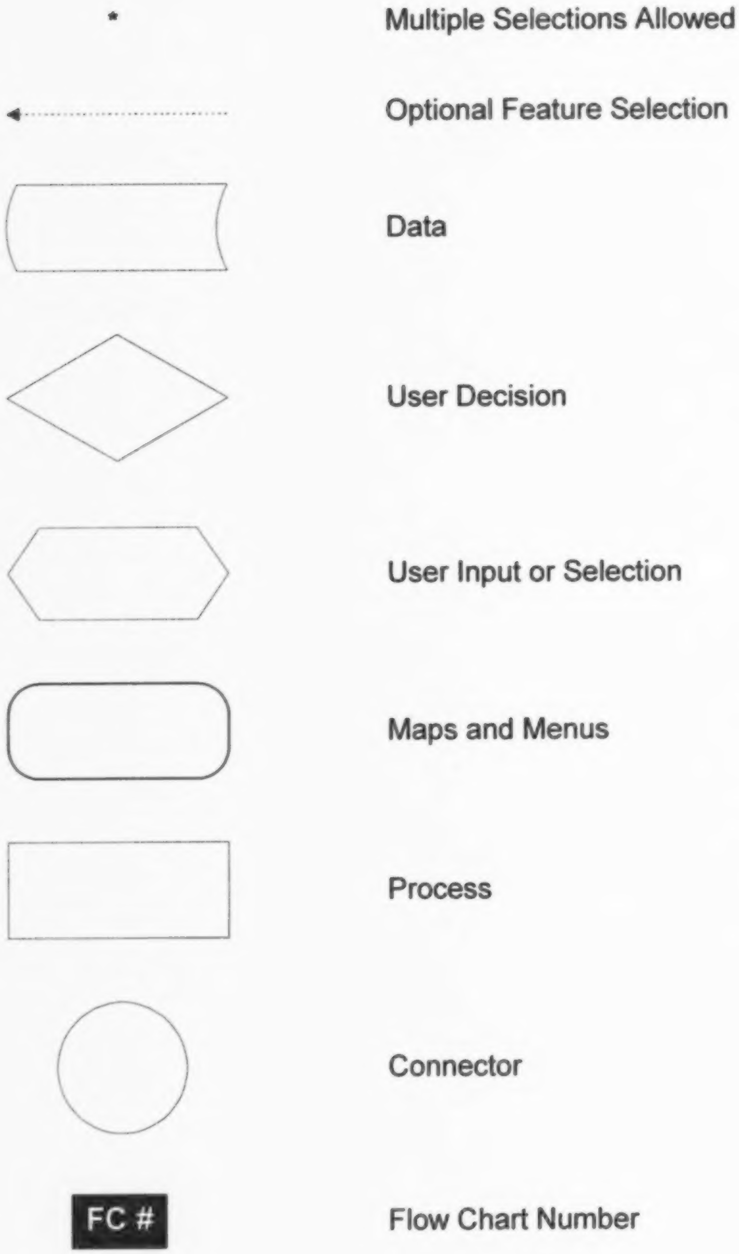
Leopold *et al.* (1964) estimated that the bankfull discharge corresponds to 1.5-year return period.

Dury Bankfull Discharge Model (Dury, 1973)

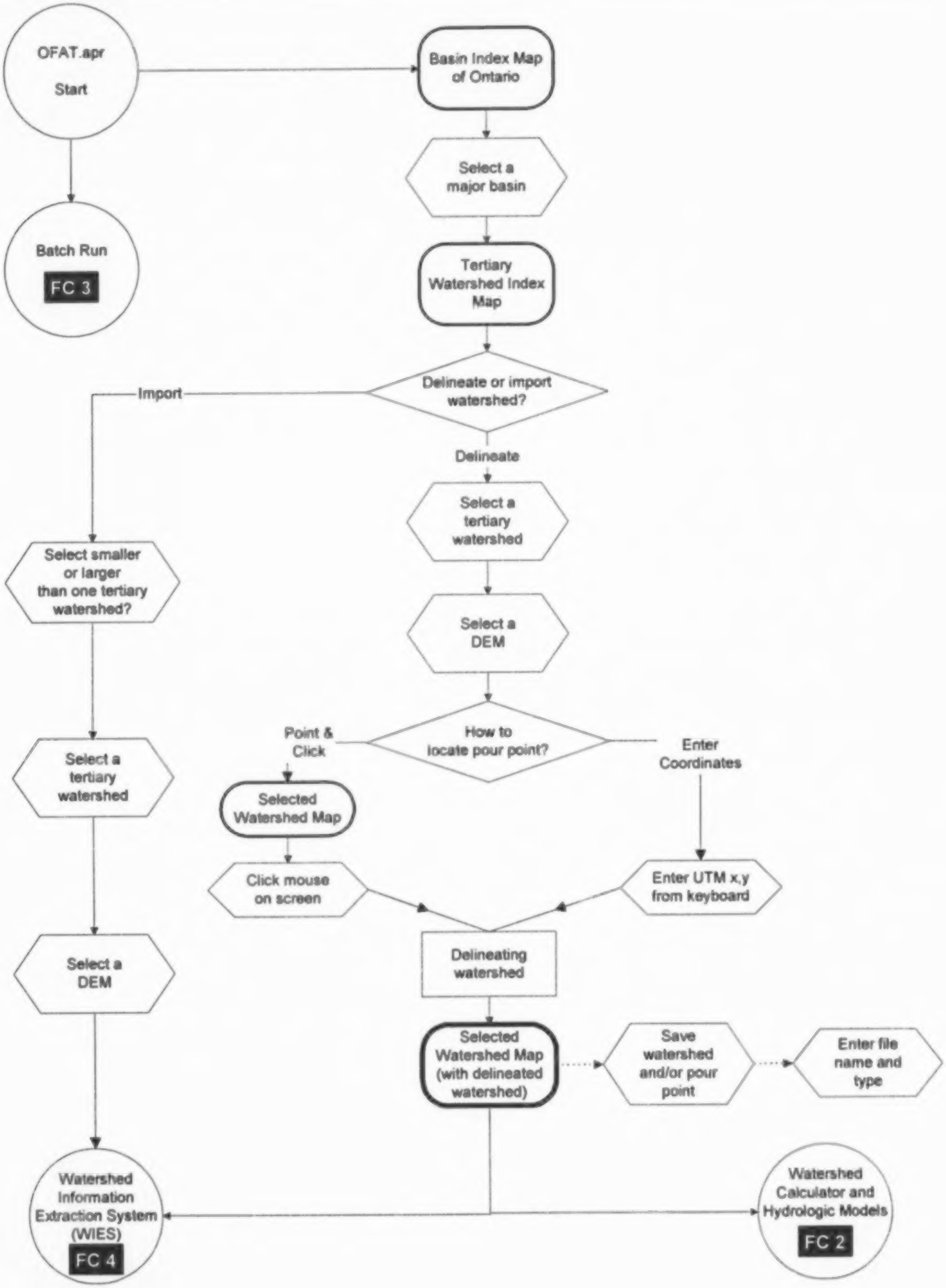
Dury (1973) estimated that the bankfull discharge corresponds to 1.58-year return period.

Appendix E: Flow Charts

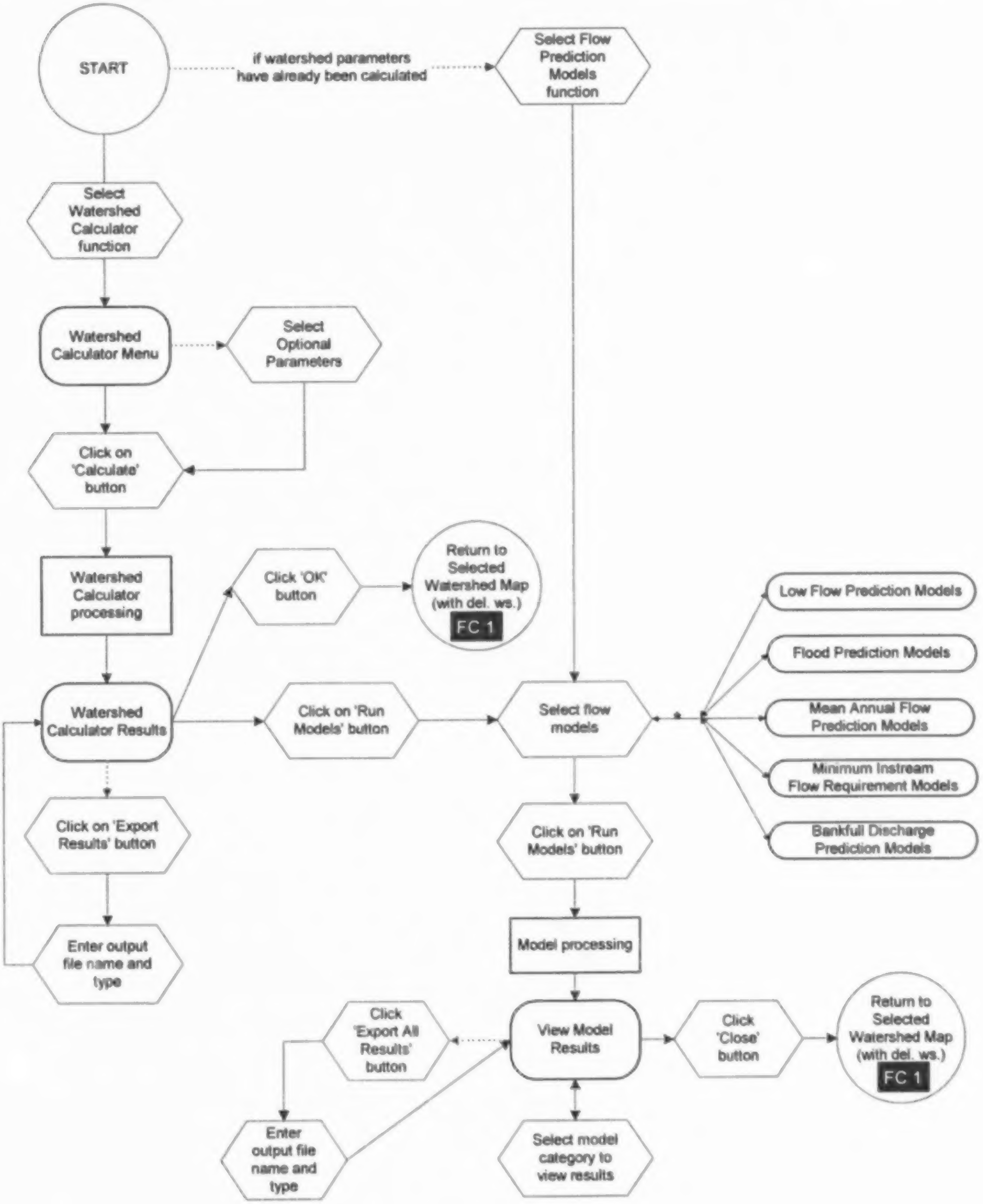
Flow Chart Legend


*
Multiple Selections Allowed
Optional Feature Selection
Data
User Decision
User Input or Selection
Maps and Menus
Process
Connector
FC #
Flow Chart Number

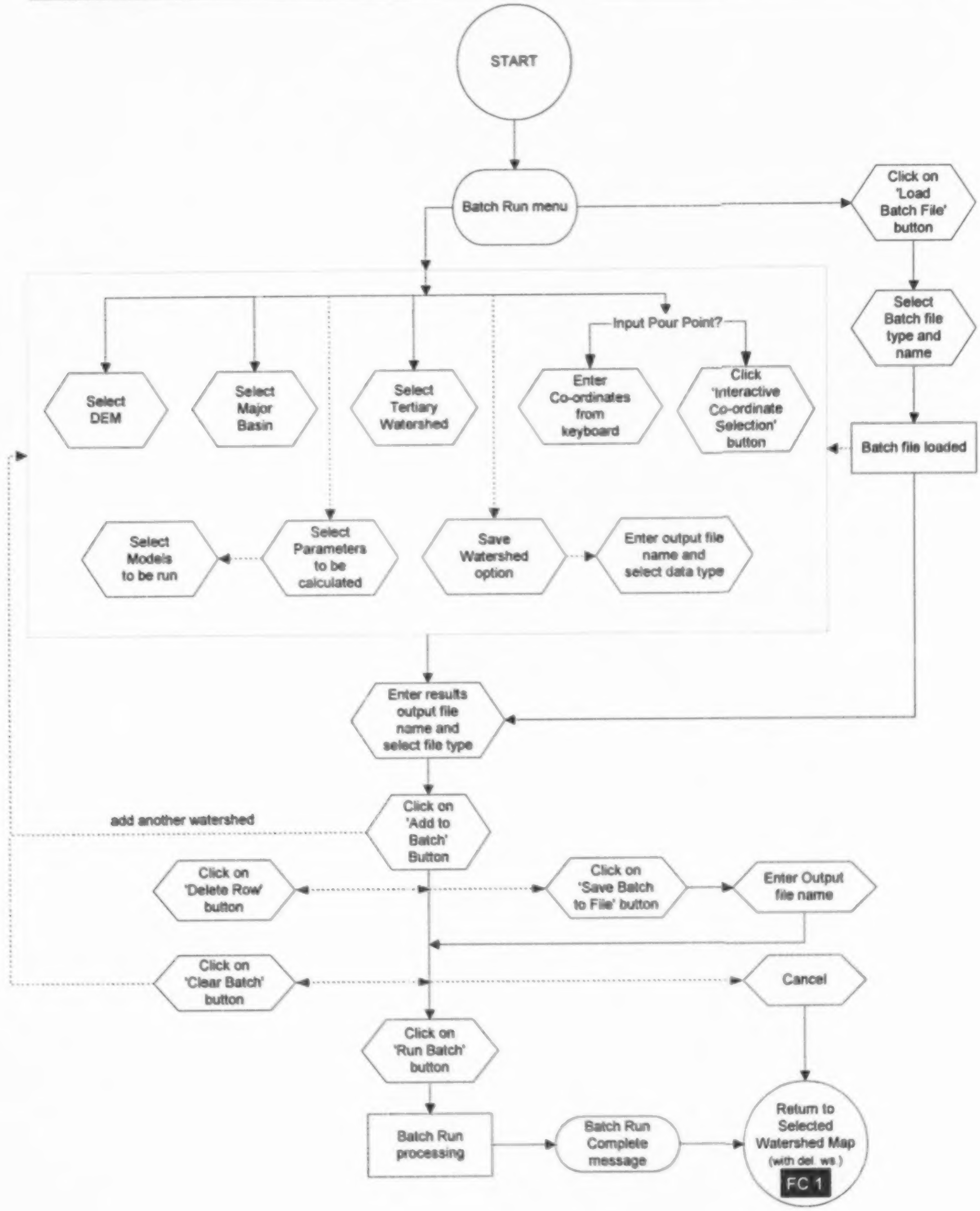
FC 1 Opening Sequences


OFAT.apr
Start
Basin Index Map of Ontario
Select a major basin
Batch Run
FC 3
Tertiary Watershed Index Map
Delineate or import watershed?
Import
Delineate
Select a tertiary watershed
Select smaller or larger than one tertiary watershed?
Select a DEM
Point & Click
How to locate pour point?
Enter Coordinates
Select a tertiary watershed
Selected Watershed Map
Click mouse on screen
Enter UTM x,y from keyboard
Select a DEM
Delineating watershed
Selected Watershed Map (with delineated watershed)
Save watershed and/or pour point
Enter file name and type
Watershed Information Extraction System (WIES)
FC 4
Watershed Calculator and Hydrologic Models
FC 2

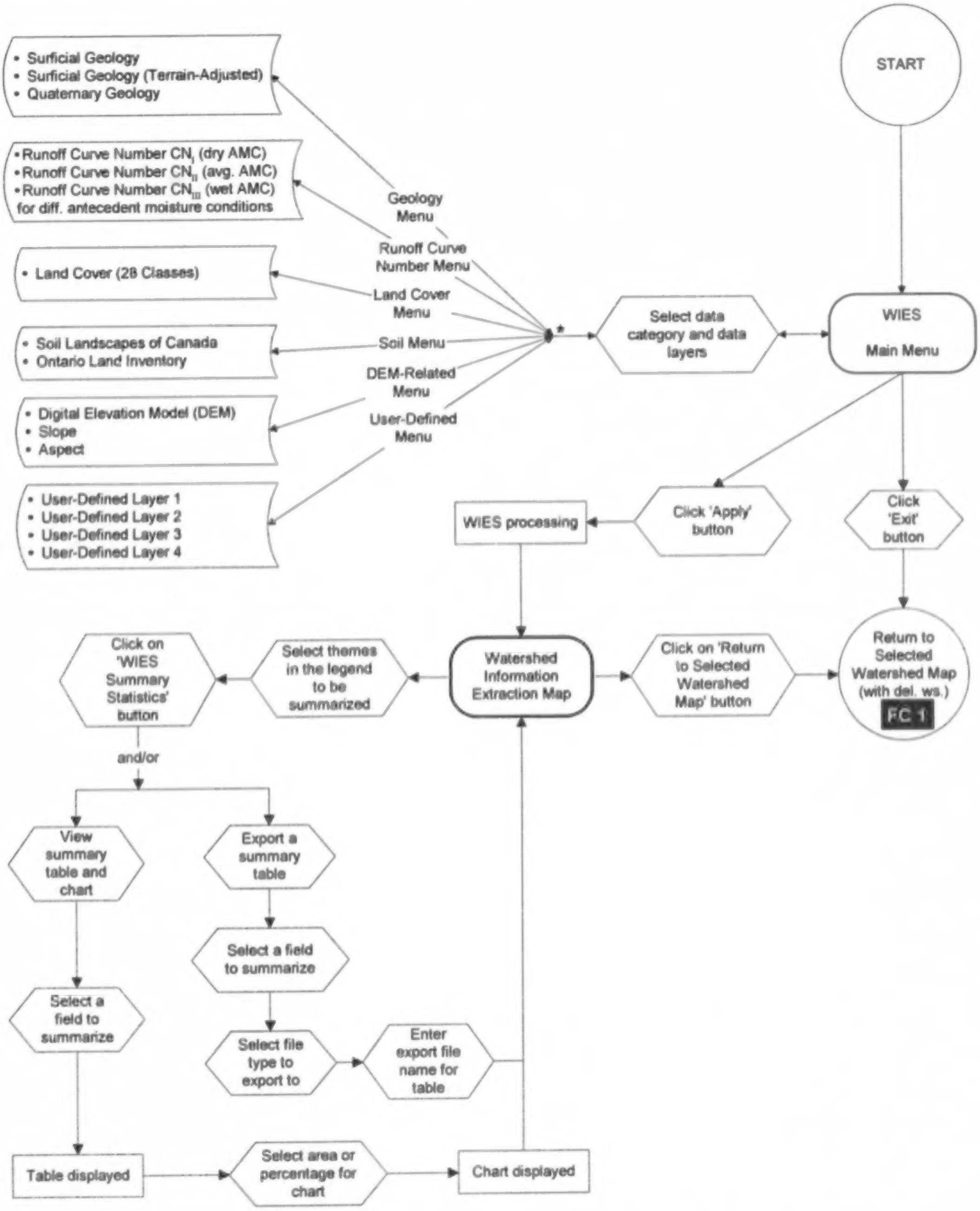
FC 2 Watershed Calculator and Hydrologic Models


START
if watershed parameters have already been calculated
Select Flow Prediction Models function
Select Watershed Calculator function
Watershed Calculator Menu
Select Optional Parameters
Click on 'Calculate' button
Watershed Calculator processing
Click 'OK' button
Return to Selected Watershed Map (with del. ws.)
FC 1
Watershed Calculator Results
Click on 'Run Models' button
Select flow models
Low Flow Prediction Models
Flood Prediction Models
Mean Annual Flow Prediction Models
Minimum Instream Flow Requirement Models
Bankfull Discharge Prediction Models
Click on 'Export Results' button
Enter output file name and type
Click on 'Run Models' button
Model processing
View Model Results
Click 'Export All Results' button
Enter output file name and type
Click 'Close' button
Return to Selected Watershed Map (with del. ws.)
FC 1
Select model category to view results

FC 3 Batch Run


START
Batch Run menu
Click on 'Load Batch File' button
Select Batch file type and name
Batch file loaded
Input Pour Point?
Select DEM
Select Major Basin
Select Tertiary Watershed
Enter Co-ordinates from keyboard
Click 'Interactive Co-ordinate Selection' button
Select Models to be run
Select Parameters to be calculated
Save Watershed option
Enter output file name and select data type
Enter results output file name and select file type
add another watershed
Click on 'Add to Batch' Button
Click on 'Delete Row' button
Click on 'Save Batch to File' button
Enter Output file name
Click on 'Clear Batch' button
Cancel
Click on 'Run Batch' button
Batch Run processing
Batch Run Complete message
Return to Selected Watershed Map (with del. ws.)
FC 1

FC 4 Watershed Information Extraction System (WIES)


START
WIES
Main Menu
Select data category and data layers
Geology Menu
Runoff Curve Number Menu
Land Cover Menu
Soil Menu
DEM-Related Menu
User-Defined Menu
*
• Surficial Geology
• Surficial Geology (Terrain-Adjusted)
• Quaternary Geology
• Runoff Curve Number CN$_I$ (dry AMC)
• Runoff Curve Number CN$_{II}$ (avg. AMC)
• Runoff Curve Number CN$_{III}$ (wet AMC)
for diff. antecedent moisture conditions
• Land Cover (28 Classes)
• Soil Landscapes of Canada
• Ontario Land Inventory
• Digital Elevation Model (DEM)
• Slope
• Aspect
• User-Defined Layer 1
• User-Defined Layer 2
• User-Defined Layer 3
• User-Defined Layer 4
Click 'Apply' button
Click 'Exit' button
WIES processing
Watershed Information Extraction Map
Click on 'Return to Selected Watershed Map' button
Return to Selected Watershed Map (with del. ws.)
FC 1
Select themes in the legend to be summarized
Click on 'WIES Summary Statistics' button
and/or
View summary table and chart
Export a summary table
Select a field to summarize
Select a field to summarize
Select file type to export to
Enter export file name for table
Table displayed
Select area or percentage for chart
Chart displayed

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